CALIFORNIA
ENERGY
COMMISSION

COSTS AND BENEFITS OF A BIOMASS-TO-ETHANOL PRODUCTION INDUSTRY IN CALIFORNIA

Draft Report

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To Be Developed

DISCLAIMER

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Introduction

As part of an on-going effort to evaluate options for the replacement of methyl tertiary-butyl ether (MTBE) in gasoline, the California legislature included in the State budget a line item to study the economic costs and benefits of a California biomass-to-ethanol production industry, which is presented in this study. The analysis presented here follows a prior study completed by the Energy Commission evaluating the possibilities for a California biomass-to-ethanol industry. This study indicated that ethanol could be produced from biomass resources with technologies that are available in the near term. Ethanol plants based on these near term technologies would be profitable and attract investors if the price of ethanol were $1.70 to $2.00 per gallon without any State support. The high cost of biomass materials and evolving status of ethanol production technology make ethanol production costly in the near term.

Ethanol produced from biomass must compete with ethanol from the Midwest and the prices of ethanol are too low to attract investment in biomass based ethanol production capacity. Even though ethanol prices are expected to rise with the phase out of MTBE, uncertainty over gasoline specifications increases the risk for investing in biomass based ethanol. State support of an ethanol industry would enhance the viability of a California ethanol industry and provide a source of ethanol that may be needed with the phase out of MTBE. Production costs and the need for State support, however, is expected to decline in the future as the technology is developed at the commercial level.

The cost of State support for an ethanol industry is compared to the potential benefits in this report. This study addresses the topics included in the State budget language. These include an assessment of economic costs and benefits of an ethanol production industry, impacts on consumer fuel prices, and impacts on rice straw burning. This report provides further depth on environmental and energy impacts.

How did California State Agencies Contribute to this Study?

This study was conducted in cooperation with California State agencies. The California Energy Commission was the lead agency. Input was received from Air Resources Board, Integrated Waste Management Board, and Department of Forestry and Fire Protection. The analysis in this study was completed by Arthur D. Little and Jack Faucett Associates under the direction of the Energy Commission.

Major Findings and Conclusions

The analysis in this report illustrates the extent of the potential economic, energy, and environmental costs and benefits of biomass based ethanol production. The main findings of this study are organized to include the economic costs and benefits, effects on consumer fuel prices, and the impact on rice straw burning.

What are the Economic Costs and Benefits?

- The analysis of economic costs and benefits was based on 200 million gallons per year of ethanol production in California. This level of production is potentially feasible with forest material, agricultural residue, and urban wastes. Feedstock scarcity increases at higher levels of ethanol production causing economic feasibility to be reduced.

- An ethanol industry results in economic benefits to the State. The economic benefits include activities related to plant construction and operation, as well as biomass collection. These activities result in jobs and personal income that might not otherwise occur in the State. In addition, an ethanol industry would also result in potential environmental and resource benefits in the form of reduced wildfire risk, reduced air emissions from fires and agricultural burning, and reduced landfilling of waste materials. The extent of these benefits is debatable and depends upon the types of feedstocks and feedstock collection practices. Another option for achieving similar environmental benefits is biomass power production. The economic benefits to the State for a 200 million gallon biomass to ethanol industry are over $500 million dollars growth in personal income (net present value basis).

- The uncertainty of the market size for ethanol is a key obstacle in attracting investor interest in ethanol production facilities. Incentives for investment in an ethanol industry in California could be State funds for fuel subsidies and capital investment. These economic costs to the State were analyzed in terms of alternative uses for State funds and related losses in economic activity.

- The economic benefits to the State of ethanol production were compared to the costs associated with a $0.20 per gallon subsidy and a 10 percent capital cost support. Under the preliminary assumptions presented in this study, the cost to the State would be about $400 million, expressed in lost personal income. The economic benefits to the State, not including environmental and resource benefits, would outweigh the costs to the State.

- Competition for biomass resources exists due to the viable biomass power industry assumed to be operating in the near and mid-term. Although ethanol production creates a by-product that can be used as fuel for electricity generation, the power production is less than if the biomass were used directly for power. As a result, competition for biomass would either cause ethanol production capacity to be underutilized or reduce net power production. Under these circumstances, capital investments from the State would be underutilized. While the biomass materials considered in this study could provide about half of the State's potential ethanol demand for MTBE replacement, they could alternatively contribute to 0.1 percent of the State's power generation capacity.

- The major benefits from using forest material biomass are reductions in emissions and damage to forest and nearby areas resulting from catastrophic wildfires, avoidance of emissions from prescribed fires designed to reduce fuel loading, and improving forest health. Potential environmental degradation from harvesting forest materials would need to be minimized with careful planning and harvesting practices. The benefits of forest thinning are a subject of controversy among environmental and industry stakeholders.

- Ethanol production would vastly reduce emissions associated with burning agricultural residue, such as orchard prunings, and it would divert 400,000 tons of urban waste from landfills throughout the State.

What is the Impact on Consumer Fuel Prices?

- Ethanol is the only approved oxygenate to replace MTBE in California. The phase out of MTBE is planned to start 2 years before the first ethanol plant could be operational in California. With the phase out of MTBE and existing oxygenate requirements, ethanol demand will increase and place upward pressure on ethanol prices which could potentially reach over $2 per gallon. A $1.00 increase in ethanol price translates into at least $0.06 per gallon increase in the cost of oxygenated gasoline, which could be passed on to the consumer.

- Ethanol production in California would displace ethanol imported from the Midwest. As a result, California ethanol producers will sell their product at the market price, which would compete with ethanol from other sources. California ethanol production, however, would not come online until at least 2 years after the planned phase out of MTBE. In the interim, the potential shortages of ethanol could impact California fuels supplies and could require the State to introduce new fuel policies.

What is the Impact on Rice Straw Burning?

- Ethanol production from rice straw will not reduce significantly the burning of rice straw. Since burning will already be severely limited by existing policy, ethanol production from rice straw will not compete with rice straw burning.

Recommendations

Recommendations will be developed following the public hearing in February.

CHAPTER I

INTRODUCTION

I. Introduction

This study was funded and mandated by California State Budget for Fiscal Year 2000-2001, Chapter 52, which provides the California Energy Commission with $250,000 to conduct a study of biomass for conversion to ethanol. The budget language further directs that this study be conducted with the assistance of other state agencies and departments and would include, but not be limited to, the following:

1. The economic costs and benefits associated with the development of a biomass-based ethanol production industry in California

2. The impact on consumer fuel costs from an in-state ethanol production industry

3. The impact on consumer fuel costs from imports of ethanol from other states

4. The impact on rice straw burning in California

5. Recommendations on future steps California should consider with regard to renewable fuel production and use in the state

This study implements one of the concluding recommendations of the Energy Commission's previous study titled, "Evaluation of Biomass-to-Ethanol Fuel Potential in California," from December, 1999. That study was prepared in response to Governor Gray Davis' Executive Order D-5-99, and it recommended that an additional study be conducted to "develop a method to determine the cost and public benefits associated with developing biomass-to-ethanol and biomass to transportation fuels industry in California."

In accordance with the above recommendation and as mandated in Chapter 52 of the California State Budget for Fiscal Year 2000-2001, the purpose of this study is to examine the costs and benefits to the state of developing an industry to produce ethanol from biomass sources.

I.1 What costs and benefits are considered in this study?

This study examines a range of impacts from a California ethanol production industry. These potential impacts are shown in Table I-1.

Table I-1. Impacts of Ethanol Production

Impact	Status/Location
State Outlays	Chapter IV
Jobs, Taxes	Chapter IV
Energy, Power Production	Chapter V
Reduced Landfill Waste	Chapter III
Project Development (research, engineering)	Appendix
Capital (Plant and Equipment)	Chapters III and IV
Operating Systems	Chapter III
Air, Water, Soil Impacts	Chapter VI
Change in Natural Resources, Land	Chapter VI
Change in Cultural and Aesthetic Resources	Not addressed
Water, Soil Quality	Chapter VI

These impacts can be treated according to the following categories:

- Economic costs and benefits
- Energy impacts with potential effect on gasoline and electricity prices
- Resource and environmental imapcts
- Aesthetic, cultural and historic impacts

The economic activities associated with an ethanol industry were analyzed according to their costs and benefits to the State. Only the activities directly related to an ethanol industry were evaluated in terms of statewide economic costs and benefits.

Due to limitations on the applicability of the economic cost/benefit analysis, energy, resource, and environmental impacts are quantified separately. The impact of an ethanol industry on aesthetic, cultural, and historic assets are not evaluated.

The benefit/cost analysis is conducted from the perspective of the state decision-maker. The question of interest is whether the economic benefits to the state outweigh the costs of state support. The cost to the State of a particular state sponsored ethanol support program is compared to the economic activity associated with a viable California state ethanol industry. The driving force for in-state ethanol production is the impending phase-out of MTBE by December 31, 2002. However, the biomass-to-ethanol industry may have other impacts that could support or dispute its implementation. For example, the use of forest materials as a feed stock for ethanol production involves collection of slashings and thinnings. Clearing of such material is likely to mitigate the danger of forest fires which may be considered as a benefit to the state.

Whether State support of other options to reduce forest fire risks provide lesser or greater economic benefits than an ethanol industry is not in the scope of this report.

The economic costs and benefits of a biomass-based ethanol production industry are narrowly defined. They result from an analysis of costs and benefits of the ethanol industry's various economic impacts on the state. The economic costs are the opportunity costs that describe the value of goods and services lost to the California economy due to the state-sponsored establishment of the ethanol industry. These costs represent the amount of money that the state, as a whole, is willing to commit in order to pursue an ethanol industry. The economic benefits, on the other hand, are the net increases in state output, employment and income that result from the establishment of a state fuel ethanol industry. These net benefits measure the value that is added to the economy due to the industry.[1] The primary economic figures of merit that were used to represent the costs and benefits to the state are personal income and employment.

It is important to note that economic costs are different from cash costs, which are expenditures related to the ethanol industry. Relevant examples of expenditures are building construction, permitting and compliance, and pre-fire management. Throughout the report, keep in mind that in many instances, cash costs are actually economic benefits since they represent capital, employment, or other additions to the economy.

In addition to the economic costs and benefits of an ethanol production industry in California, this study assesses the effects that such an industry would have on energy use and the environment. These effects are described in detail following the discussion of economic costs and benefits.

The impact of ethanol use on consumer fuel costs is also included in this report. Ethanol production in the State results in an additional source of transportation fuel that would be blended with gasoline. It is important to understand how fuel prices will react to ethanol produced in-state or imported from other states. This study discusses how oxygenate or octane requirements may effect fuel prices in the event of an ethanol shortage. Ethanol production would also affect the production and consumption of electric power in the State.

Finally, the impact of in-state ethanol production on rice straw burning has been a major area of interest. The likelihood of rice straw being used as a feedstock and the impact on rice straw burning are analyzed.

This report discusses the above issues, sensitivities in the study's findings, and recommends future steps California should consider with regard to a biomass-based ethanol industry in the state.

[1] An ethanol industry results in activities that produce both positive and negative impacts on the State economy. Under most circumstances the positive economic impacts are greater than the negative impacts; so the term benefit is applied to the net impacts.

I.2 How Is This Report Organized?

This report has been written with the general audience in view. The following describes the organization of this report and the contents of each chapter:

Chapter II, "Ethanol as a Fuel – Background," discusses the uses of ethanol as a motor fuel and explains how air quality regulations affect the demand for ethanol. This chapter also describes past and proposed ethanol projects in California. It examines the potential for ethanol production in California and discusses the types and locations of feedstocks available for California ethanol production, as well as their cost. The roles of Federal and State tax incentives in encouraging ethanol production are also discussed.

Chapter III, "Analysis of an Ethanol Production Industry in California," describes possible scenarios and sources of California ethanol production. A section describing ethanol plant operations contains an assessment of the availability of different feedstock sources, including rice straw. This chapter identifies the impacts of ethanol production in California. The economic feasibility of collecting and transporting different feedstock sources is also discussed.

Chapter IV, "Economic Costs and Benefits of In-State Ethanol Production," provides a general overview of how economic costs and benefits are analyzed and describes the economic impact assessment methodology used for this report. It identifies the capital expenditure involved in ethanol plant construction, operation, and maintenance. This chapter also discusses tools for measuring inputs and types of economic impacts, in general, and ethanol production impacts, in particular. This chapter assesses the total economic impacts of California ethanol production and sales. It shows how ethanol plant construction results in economic output in California and illustrates the economic impacts of plant operation. The effects of a California ethanol production industry on employment are assessed.

Chapter V, "Effects of California Ethanol on Energy Use," discusses what potential effects ethanol production would have on electricity, fossil fuel, and petroleum production and use. This section explores two different power production scenarios, one of which is analyzed further in the ethanol study. It describes the relationship between both imported and California ethanol industries and fuel prices and how gasoline prices affect the ethanol industry.

Chapter VI, "Effects of California Ethanol Production on the Environment," assesses the potential emissions impacts of ethanol plant operations and transportation. It looks at both the negative and positive effects of forest material harvesting on forest soil, forest health, water resources, wildfire, and forest food chain, fish, and wildlife. This chapter explains how the benefits of biomass-for-ethanol removal would mitigate the adverse impacts, if conducted in appropriate forest sites using appropriate collection methods.

Chapter VII, "Sensitivity Analysis," evaluates how the price of ethanol, electric power, and natural gas, as well as, the availability of biomass feedstocks and governmental tax incentives would affect the assumptions utilized in the report.

Appendices include documentation, additional information, and technical details for each chapter. The appendices are presented as a separate volume to the main report.

CHAPTER II

ETHANOL AS A FUEL — BACKGROUND

II. Ethanol as a Fuel — Background

This chapter summarizes the uses of ethanol as a motor fuel, the role of federal and state tax incentives in fostering an ethanol market, federal and state air quality regulations affecting ethanol use, and the current status of ethanol production and use in California.

II.1 What Are the Uses of Ethanol as a Motor Fuel?

Alcohols have been used as fuels since the inception of the automobile. The term alcohol often has been used to denote either ethanol or methanol as a fuel. With the oil crises of the 1970s, ethanol became established as an alternative fuel. Countries including Brazil and the United States promoted domestic ethanol production. In addition to the energy rationale, ethanol/gasoline blends in the United States were promoted as an environmentally driven practice, initially as an octane enhancer to replace lead. Ethanol also has value as an octane booster in clean-burning gasoline to reduce vehicle exhaust emissions.

In the United States, ethanol supplies account for about one percent of the highway motor vehicle fuel market, in the form of a gasoline blending component. Currently, most of this ethanol is used in a 10 percent blend with gasoline traditionally referred to as “gasohol,” a term which is being replaced with “ethanol/gasoline blends” or “E10.” Lower percentage blends, containing 5.7 percent or 7.7 percent ethanol are also being used in some areas to conform to air quality regulations affecting the oxygen content of reformulated gasoline. The 5.7 percent blend is the formulation that would be used in California to meet a 2 percent by weight oxygenate requirement.

In addition to ethanol/gasoline blend markets, ethanol has other motor fuel applications including:

- Use as E85, 85 percent ethanol and 15 percent gasoline, in specially prepared vehicles. Some new gasoline vehicle models are being produced as flexible fuel vehicles (FFVs), capable of using E85 or gasoline in any combination.

- Use as E100, 100 percent ethanol with or without a fuel additive. Demonstration fleets of heavy-duty buses and trucks with specially designed engines adapted from diesel engines have been operated on this fuel.

- Use in Oxydiesel, typically a blend of 80 percent diesel fuel, 10 percent ethanol and 10 percent additives and blending agents. This fuel is being demonstrated in fleets of buses with unmodified diesel engines.

II.2 How Do Air Quality Regulations Affect Markets for Ethanol?

The regulatory climate of fuel policy has and will continue to play a critical role in determining ethanol demand. Complying with existing oxygenate standards creates the need for oxygen-containing blending components, other than MTBE, to be included in reformulated gasoline. As these restrictions and thresholds vary, so does the demand for ethanol.

Current Federal oxygenate standards require fuel in ozone non-attainment areas to have approximately 2.0 percent oxygen by mass. This can be achieved by blending 5.7 percent ethanol and 94.3 percent gasoline by volume. Based on internal references (1), nearly 70 percent of California's gasoline is currently consumed in non-attainment regions. Based on 1999 California gasoline consumption of 14.5 billion gallons (1), California would require roughly 10.1 billion gallons of 2.0 percent oxygenated gasoline. To produce 10.1 billion gallons with 2.0 percent oxygen, approximately 580 million gallons of ethanol would be blended with 9.6 billion gallons of non-oxygenated gasoline.

By 2004 it is estimated that California's annual gasoline consumption will reach 15.7 billion gallons. It is also estimated that the San Joaquin Valley will be reclassified as an ozone non-attainment region (1). This reclassification will push the current 70 percent oxygenated gasoline demand up to 80 percent, as oxygenated gasoline will be required in the San Joacquin Valley. The ethanol demand that would result from increased gasoline consumption and a broader oxygenated gasoline is approximately 715 million gallons annually.

It is also worth noting that California has requested a waiver from the federal oxygenate standard. If that waiver were granted, then the proposed ethanol demand levels could change greatly from the figures listed above. If a complete waiver were allowed, ethanol demand for oxygenate would disappear entirely, though it is very likely that ethanol would be used as a blending component to augment fuel volume, or to increase octane ratings. A partial waiver would affect the ethanol demand linearly with the prescribed thresholds.

To replace the energy supplied by 9.5 billion gallons of MTBE-blended gasoline, 550 million gallons per year of ethanol must be mixed with approximately 9.1 billion gallons per year of conventional gasoline, for a total of 9.65 billion gallons per year. The increase in fuel volume is necessary, due to the lower energy content of ethanol, compared to gasoline. These demand levels are direct consequences of meeting a) the federal oxygenate standards for ozone non-attainment regions, and b) current California gasoline energy demand.

Leaving energy demand constant, air quality attainment influences the demand for ethanol. If attainment regulations were made more stringent, then ethanol demand could increase if more regions fell into non-attainment status. Conversely, if attainment thresholds were relaxed or removed entirely, then ethanol demand would subsequently decrease.

In addition to statewide demand levels, air quality regulations also influence specific ethanol markets. Because emissions attainment is assessed on a regional basis, oxygenate demand is divided into discrete markets. As a result, gasoline intended for sale in California would require region-specific blends. This could clearly impact refinery and blending terminal logistics. Moreover, oxygenate blending components such as ethanol will need to be distributed to the regions that require oxygenated fuels. Since ethanol production capacity is likely to be based on locally available feedstocks, as explored in this study, the oxygenate transportation distance to market would vary greatly. Given that transportation distance plays a significant role in the financial feasibility for a proposed ethanol industry, the dynamic regional demand for oxygenated fuel is a factor.

II.3 What is Happening with Ethanol in California?

California's experience with ethanol fuel includes a number of project feasibility studies, a few demonstration projects, and several small commercial ventures.

Biomass to Ethanol Technology Status

A number of biomass-to-ethanol processes are at various stages of evolution. Of these, the two-stage dilute acid hydrolysis process is commercially the most proven technology. Table II-1 presents the other technologies and their status. In this report, all references to ethanol production unless specifically stated, imply the two-stage dilute acid process.

Table II-1. Status of Biomass to Ethanol Technologies

Biomass to Ethanol Process	2-Stage Dilute Acid	2-Stage Conc. Acid	Enzymatic	ACOS[a]
Overall Status of Technology	Commercial	Pilot	Laboratory	Laboratory

[a] ACOS – Acid Catalyzed Organosolv Saccharification Process

Past Ethanol Projects in California

Between 1980 and 1983, the Energy Commission investigated alcohol fuels including examinations of several potential ethanol production projects. Most of these prospective projects were judged not viable, based on various economic, technical, and environmental factors.

In 1997, the Energy Commission collaborated with the National Renewable Energy Laboratory to investigate potential biomass-to-ethanol production in the San Joaquin County with the STEP 2 (Sustainable Technology Energy Partnership) Project. The STEP 2 project resulted in preliminary design data for a biomass ethanol demonstration plant, including a feedstock availability report, bench-scale ethanol production process testing, and other process-related research.

The California Department of Food and Agriculture (CDFA) has also conducted ethanol production feasibility and demonstration programs, such as the California Alcohol Fuel Plant Design Competition and the 1990 Energy and Chemical Feedstock Crop Demonstration Program.

The Qunicy Library Group (QLG) with the assistance of various expert groups conducted a study (reported in November in 1997) evaluating the feasibility of ethanol manufacturing in northeastern California.

The California Integrated Waste Management Board recently undertook a feasibility study of alternative methods of utilizing various types of agricultural and forestry residues, including application as feedstock for ethanol production (2). The report generally describes a bright future for beneficial commercial applications of these types of wastes and residues that will reduce the need for traditional disposal practices. Energy applications, including ethanol production, were seen as candidates among a variety of other promising uses.

Parallel products, a resource management company in Southern California, produces between 6 and 12 million gallons of fuel-grade ethanol per year using residuals from the food and beverage industry.

Proposed Ethanol Projects in California

In the 1990s, California witnessed renewed interest in ethanol production, with several new biomass-to-ethanol projects in the planning and development stages. These proposed projects all intend to use some type of waste or residue feedstocks and to use advanced production processes to produce ethanol, electricity, and other coproducts.

BC International, Gridley Ethanol Project

BC International Corporation, of Dedham, Massachusetts, is pursuing development of a biomass-to ethanol facility in Butte County. The Corporation has a proprietary patented processing technology for producing ethanol. The Gridley plant, located in the center of the state's rice-growing region, intends to use rice straw as a partial feedstock. The traditional practice of burning rice straw is being phased out under California legislation, creating interest in alternative applications for this residue, including ethanol production. The proposed site is adjacent to an existing biomass electric power plant, offering the potential to combine electricity generation and ethanol production from the same biomass feedstocks. The Gridley project would be BC International's second commercial venture, following a project of this type currently under development at a former petroleum refinery and grain-to-ethanol site in Jennings, Louisiana. Both the Energy Commission and the U.S. Department of Energy have provided early funding support to develop the Gridley project, of which the City of Gridley would be a major partner and operator.

BC International, Collins Pine Ethanol Project

BCI and the Collins Companies, a timber firm, are planning a biomass-to-ethanol plant at an existing biomass electric power plant in Plumas County. A study team has completed a feasibility study of this facility, which would use forest thinnings and wood wastes as feedstocks (4). The team was headed by the Quincy Library Group, a forum for California environmental organizations, county officials, and timber industry groups seeking solutions to the accumulation of excess woody material in the Plumas and Lassen National Forests. Ethanol production is seen as one attractive option for beneficial application of forest material that needs to be harvested to lessen the potential for catastrophic wild fires and related forest health problems. The Energy Commission and U.S. Department of Energy have provided early funding support for this project.

II.4 What is the Potential for Ethanol Production in California?

A prior study was conducted by the Energy Commission to evaluate the potential of biomass ethanol in California (2). The study investigated the types of feedstocks that are available in California and the cost of ethanol production.

Types and Locations of Feedstocks Available for California Ethanol Production

California has substantial waste and residual biomass materials because of its rich agricultural and forestry resources and its large volume of commercial and municipal solid wastes. Roughly 50 million bone dry tons of biomass residue are produced annually in the State. While this amount of material could theoretically be converted to three billion gallons of ethanol per year, the actual potential production is lower. In order to produce ethanol, the feedstocks must be collected at a reasonable cost, have high cellulose content, and be close to potential ethanol production facilities. As discussed in Chapter III, sufficient feedstocks for 200 million gallons per year of production capacity can be readily identified with about 400 million gallons per year corresponding to a more extensive use of available feedstocks.

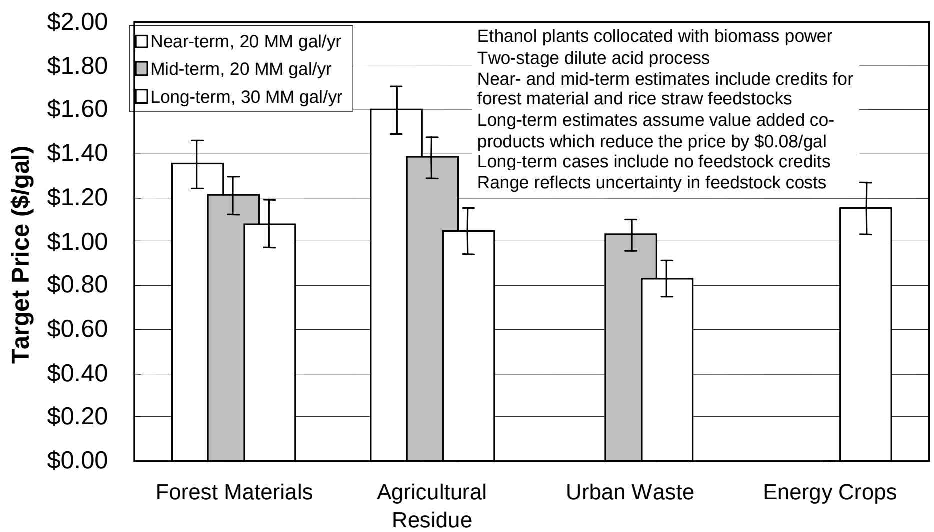
The Energy Commission study of 1999 assessed the near-term potential for ethanol production by focusing on available feedstocks in close proximity to biomass power plants or potential ethanol production facilities. These conventional biomass residues included primarily forest material near existing biomass power plants, agricultural residue, and urban waste processed in many small facilities. Additional materials for ethanol production are available in the state, but these cost more.

Central and Southern California forests have been subject to damage from insects, drought, and catastrophic wildefires and could likely benefit from thinning. However, these forests are not located close to existing biomass power plants and forest roads are limited. Trees such as eucalyptus could be grown as feedstocks or grain crops could also provide feedstocks for ethanol production. These feedstocks would provide over 600 million gallons per year of production capacity, but at higher cost.

Following the conclusions of the 1999 Energy Commission report, the principal feedstock sources considered in this study are thinnings from northern California forests, agricultural residue in the Central Valley, and limited urban waste. There is ongoing discussion as to the environmental effects that large scale biomass removal might have. While this report considers ethanol production partially based on forest thinning biomass, it is not necessarily an endorsement of forest thinning practices. The long term environmental issues posed by biomass removal, which were considered in Chapter VI, still require further study and discussion.

The Cost of Ethanol Production in California

The production cost of ethanol from these sources was evaluated in the 1999 Energy Commission study. The results were presented in terms of the required sales price needed for profitable plant operation, identified as the "Target Price" in Figure II-1. The actual price of ethanol depends upon market conditions, which are largely beyond the control of the ethanol producer. The target price represents a sales price where an ethanol plant would be sufficiently profitable to attract investor participation. This target price includes operating costs, debt service, and return on investment (CEC1999). The target prices in Figure II-1 are based on fuel ethanol that is blended with up to 5 percent gasoline.[2] Actual ethanol prices can be low under surplus conditions and higher when supplies are limited as discussed in Chapter V. These results are based on ethanol plants that are collocated with existing biomass power plants for forest material and agricultural residue. The ethanol target prices vary from near-term to mid-term to long-term time horizons, which drop as process efficiency improves and production costs drop over time.[3]



Source: Biomass-To-Ethanol Fuel Potential in California, California Energy Commission, 1999.

Figure II-1. Economic fuel ethanol prices decrease with advances in technology

[2] Gasoline is added to ethanol as a denaturant, to prevent drinking of the fuel.

[3] Near-term, midterm, and long-term time horizons correspond to 2003, 2007, and 2012, respectively.

The target prices are based on the cost of production. For the analysis in Figure II-1, State support for ethanol production was assumed in the near- and mid-term. The principal mechanism for support was a credit for forest material feedstock of $30/ton or $0.36/gal. The $30/ton value has been analyzed as a level of funding required to make the removal forest thinnings economically attractive (NREL 1998). This subsidy is however currently not available.

The near-term and mid-term forest material cases assume this feedstock credit or subsidy of $30/ton or about $0.36/gallon of ethanol. This subsidy is eliminated for long-term plants. This feedstock credit would be one cost to the State for supporting an ethanol industry. The benefits to the state were analyzed and compared to the cost to the state for this level of support in the 1999 Energy Commission study. The ethanol production yield for the various feedstocks is shown in Table II-2.

Table II-2. Ethanol Production Yield (gallons/bdt) from Biomass Residue Feedstocks

Feedstock	Timeframe		
	Near-term	Mid-term	Long-term
Forest Material	77.4	77.4	81.5
Agricultural Residue	62.4	64	77.5
Waste Paper	74.4	81.7	98.9
Mixed Urban Waste	—	76.8	92.6

Source: CEC 1999

II.5 What is the Status of Tax Incentives?

Federal Tax Incentives

In 1978, Congress enacted the first tax incentive for ethanol, a fuel excise tax exemption. Originally, this incentive was a full exemption from the 4 cents per gallon gasoline tax that applied at the time. Currently, two types of federal tax incentives apply to biomass-derived ethanol sold as fuel: (1) a partial excise tax exemption and (2) income tax credits. Table II-3 traces the history of the federal ethanol tax incentives to date.

As the federal gasoline excise tax has increased to 18.3 cents per gallon, the excise tax exemption on ethanol has also increased somewhat, to 6 cents per gallon before being reduced to the current 5.4 cents per gallon. The key point is that the full exemption, 5.4 cents per gallon, applies to ethanol/gasoline blends, which are 10 percent ethanol. Proportionately lower amounts apply to lower ethanol/gasoline blends, 7.7 percent and 5.7 percent blends. In effect, this exemption structure provides a 54 cents per gallon exemption from excise taxes for each gallon of ethanol that is blended with gasoline.

Table II-3. Taxes and Tax Exemption for Ethanol/Gasoline Blends

Year	Prior to 1978	1978-82	1982-84	1984-90	1990-93a	1993-2000	2001-02	2003-04	2005-07
Federal Gasoline Excise Tax (cents/gallon)	4	4	9	9	14	18.3	18.3b	18.3b	18.3b
Excise Tax Exemption for 10% Ethanol Blends (cents/gallon)	—	4	5	6	5.4	5.4	5.3	5.2	5.1
Blender's Income Tax Credit for Ethanol (cents/gallon)	—	—	40 (as of 1980)	60	54	54	53	52	51
Fed Energy Tax	—	—	—	—	4.3	4.3	4.3	4.3	4.3
CA Ethanol Tax Exemption (cents/gallon)	—	—	3	—	—	—	—	—	—
CA Excise Tax (cents/gallon)	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5

[a] Small producer's credit added in 1990 (10 cents/gallon for first 15 million gallons for qualified small producers with annual output less than 30 million gallons). Excise tax exemption became applicable to 7.7 percent ethanol blends (currently 4.158 cents/gallon) and 5.7 percent ethanol blends (currently 3.078 cents/gallon) as of 1992.
[b] Assuming current gasoline tax rate is maintained.

In place of the excise tax exemption discussed above, certain businesses can take one of the following income tax credits:

(1) A 54 cents per gallon credit for each gallon of blended ethanol.

(2) The same 54 cents per gallon credit for the sale or use of neat alcohol (neat alcohol is defined as fuel with 85 percent or more alcohol).

In addition, a small ethanol producer is allowed a credit of 10 cents per gallon for each gallon of ethanol produced up to 15 million gallons.

In 1998, Congress voted to extend the ethanol tax incentives until December 31, 2007. The effective amounts of the incentives, however, are to be reduced from the current 54 cents per gallon level to 53 cents in 2001 and 2002, 52 cents in 2003 and 2004, and 51 cents in 2005 through 2007. The issue of continuance of the incentives is likely to be debated again before the 2007 sunset date.

The net cost of ethanol as a blending component is 54 cents per gallon less than the market price because of the federal excise tax exemption. By most estimates, this figure amounts to roughly one-half the actual wholesale cost to produce ethanol, allowing ethanol to enter the fuel market at a cost closer to that of gasoline on an energy equivalent basis.

State Tax Incentives

At least 30 states, including California, have adopted their own ethanol tax incentives at one time or another, with most patterned after and adding to the federal incentives. Appendix II-A includes a summary of the current ethanol incentives applicable in various states.

From 1981 to 1984, California had a state ethanol incentive in the form of a 3 cents per gallon exemption for 10 percent ethanol/gasoline blends from the state gasoline excise tax, which was then 7 cents per gallon. This excise tax exemption amounted to a 30 cents per gallon incentive for ethanol blended this way. Since the sunset of California's incentive, ethanol/gasoline blends are assessed the full state gasoline excise tax, now 18 cents per gallon.

Neat alcohol fuels are taxed at one-half the prevailing California gasoline excise tax rate. For ethanol in the form of E85, this rate represents about 70 percent of the gasoline excise tax rate on an energy equivalent basis. California also has an alcohol fuel tax credit program that has not yet been funded by the Legislature in order to be implemented. The program was created in 1988 under SB2637 and would provide a 40 cent per gallon production incentive for liquid fuels fermentable from biomass resources in California.

In sum, air quality regulations determine ethanol demand. As MTBE-blended gasoline is phased out, the demand for substitute oxygenate blending components such as ethanol should increase. The cost of ethanol production in California is dependent in part on the actual price of ethanol, which is in turn dependent upon market conditions of supply and demand. Government tax incentives could help in fostering an ethanol industry that is adequately profitable. The following chapter provides a more detailed assessment of potential scenarios and sources of California ethanol production and identifies the impacts it would have on the State.

References

(1) Personal communication with Gordon Schremp, CEC Fuel Resources Office.

(2) Evaluation of Biomass-to-Ethanol Fuel Potential, CEC, December 1999

CHAPTER III

ANALYSIS OF AN ETHANOL PRODUCTION INDUSTRY IN CALIFORNIA

III. Analysis of an Ethanol Production Industry in California

The purpose of this section is to offer an overview of the scenarios considered in this report. Additionally, the types of costs and benefits resulting from an ethanol production industry are discussed.

The complete economic costs and benefits are based on a scenario that includes ethanol related activities only within California. Within California, it covers the ethanol industry impacts from initial material gathering to the point where ethanol is delivered to the terminal, the key elements of which are shown in Figure III-1. One major exception to the California-only scenario is the impact of CO_2 emissions, which has global implications. Therefore, the impact of related out-of-state CO_2 emissions are considered in this study. This accounts for the differences between using ethanol produced in California and that produced outside of the state. The effect of California ethanol production on CO_2 emissions is discussed more fully in Chapter VI.

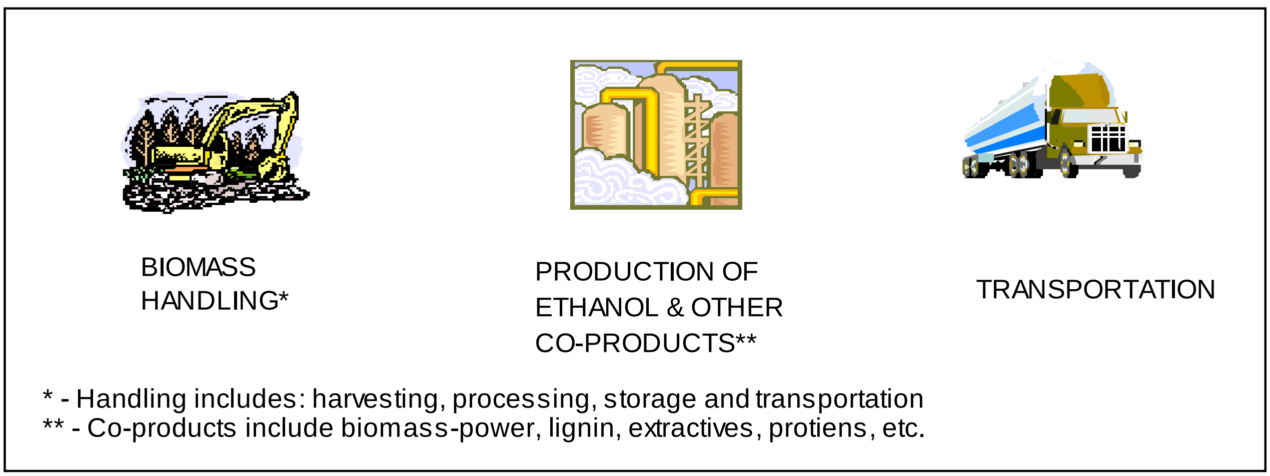


Figure III-1. Elements Affecting California Ethanol Industry

III.1 Scenarios for Ethanol Production

The impacts of ethanol production depend on the types of ethanol plants, amount of ethanol produced, and to some extent the total statewide ethanol usage, in conjunction with either zero, moderate, or high California ethanol production. Figure III-2 below summarizes each scenario in terms of ethanol volumes for assumed in-state production as well as imported ethanol.

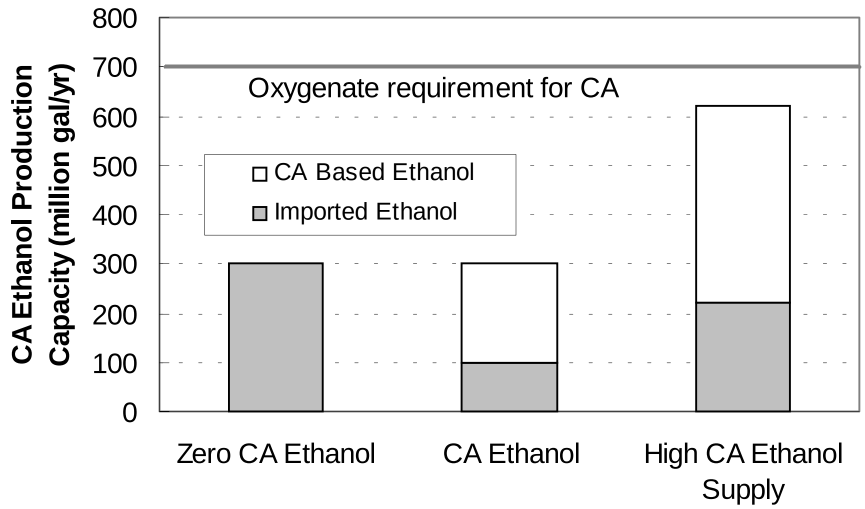


Figure III-2. Ethanol Production Scenarios

The California ethanol production scenario considered within this report is based on a statewide demand of 300 million gallons of ethanol per year, of which 200 million gallons are produced in-state. While additional biomass is available as feedstock, the materials necessary to produce 200 million gallons are more accessible and therefore are economically more feasible than a larger-scale production. The other scenario is wherein no ethanol (Zero CA-Ethanol) is produced in California and the entire 300 million gallons are imported. Scenarios for ethanol usage are categorized as either moderate (300 million gallons/year) or high demand (600 million gallons/year). This former level of usage is analyzed. These circumstances assume that the oxygenate requirement for California gasoline is mildly relaxed, and that the majority of easily accessible biomass will be collected and used to produce ethanol. Under this relatively conservative ethanol demand scenario, California-based ethanol production sources would be unable to provide all of the ethanol necessary by the time complete phase out of MTBE by December, 2002, is implemented. Therefore, the remaining ethanol demand would be satisfied by importing ethanol from sources outside of California. National ethanol production is estimated at 1.6 billion gallons annually, and California demand would account for nearly 20 percent of the nationwide supply. Figure III-3 presents the timeline for California ethanol production based on this report.

This demand scenario is based on the California Energy Commission fuel consumption data, which indicates that statewide gasoline consumption was approximately 14.5 billion gallons in 2000. All scenarios considered within this study assume a constant energy content within the pool of gasoline and ethanol. It might seem that any ethanol added to the fuel inventory would marginally displace gasoline. It is worth noting, however, that blending with ethanol boosts the vapor pressure in gasoline. As a result, the lighter hydrocarbon chains, particularly butanes and pentanes, contained in gasoline must be removed if the resulting ethanol-gasoline blend is to meet seasonal Reid Vapor Pressure requirements for evaporative emissions. As a result, ethanol-blending renders a fraction of the gasoline pool unusable in the blending process.

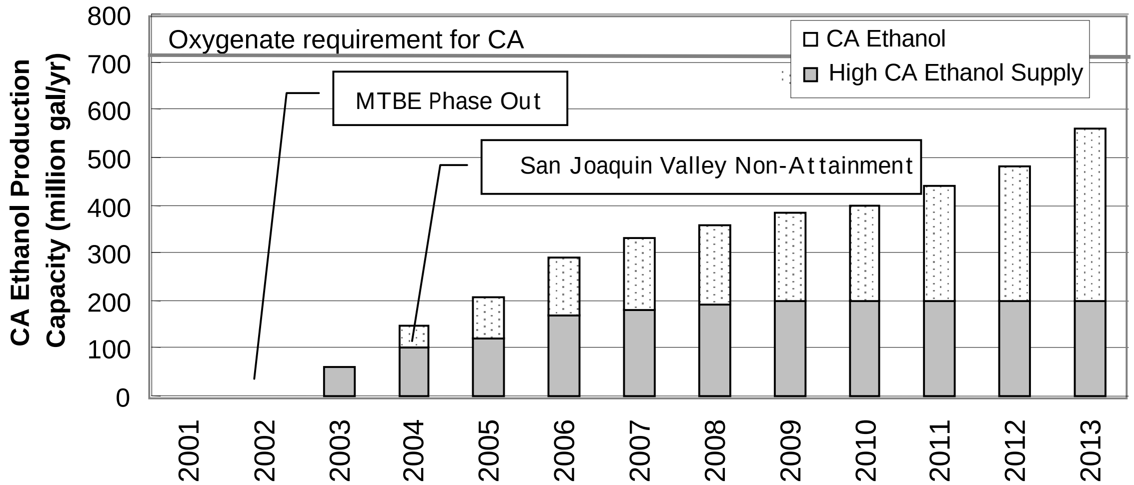


Figure III-3. Ethanol Production Potential Timeline

The extracted pentanes can be used as fuel for the refining process, or as an export to chemical processing operations. The 2000 MathPro analysis of California Phase 3 reformulated gasoline suggest that every gallon of ethanol blended requires removal of approximately 1 gallon of pentanes to meet Reid Vapor Pressure standards (CEC 1999c).

Ethanol production influences electricity as well as fuel energy impacts. Where feedstocks and siting requirements are compatible, ethanol plants can be collocated with biomass power plants. As such, electricity is a by-product of the ethanol conversion process that can be sold to utilities. This results in a secondary revenue stream for ethanol manufacturers and could help California meet increased electricity demands. However, under the current climate of a severe electric power shortfall, biomass-based power plants will compete with the ethanol plant for feedstock. This issue is discussed in latter sections.

III.2 What are the Sources of California Ethanol?

California ethanol production potential is examined for three biomass sources: forest materials, agricultural residues, and urban waste. Forest materials and agricultural residues, were assumed to be collected within a radius (of 25 to 40 miles) around each ethanol plant. Urban waste is assumed to be sorted at existing Material Recovery Facilities (MRFs).

A total of twenty-one potential biomass to ethanol plants were considered. Table III-1 presents a brief description of the location, size and/or quantity of biomass available from the region sorrounding each biomass plant. Of these twenty-one plants, nine plants were selected to produce the assumed scenario of 200 million gallon per year production of California-ethanol. A detailed description of the analysis leading to the assumed quantities is presented in the Appendices.

It is assumed that, both forest material and agricultural residue plants are dispersed such that each ethanol facility has a sufficient area for biomass collection. By contrast, urban waste plants tend to be clustered around urban areas, collocated with existing MRFs, where existing waste materials are already collected. The assumed scenario for biomass feedstock distribution is shown in Figure III-4. Based on existing biomass densities and current MRF waste capacities, Figure III-5 presents the assumed quantity of biomass for each source-type for 200 million gallons in-state ethanol production.

Table III-1. Feedstock Availability – Potential Sources and Quantities

Plant ID	Plant Location	Feedstock Collection Area Radius (miles)	Forest Residues (BDT)	Agricultural Residues (BDT)	Urban Waste (BDT)	Plant Capacity (M Gal/yr)
1	Weed	40	520,000	---	---	40
2	Chester	40	520,000	---	---	40
3	Loyalton	25	260,000	---	---	20
4	Andersen	25	260,000	---	---	20
5	Susanville	25	260,000	---	---	20
6	Weaverville	25	260,000	---	---	20
7	Gridley	40	---	640,000	---	40
8	Woodland	40	---	640,000	---	40
9	Delano	25	---	310,000	---	20
10	Fresno	25	---	310,000	---	20
11	Riverside	25	---	310,000	---	20
12	Los Angeles	-b-	---	---	110,000	10
13	Orange County	-b-	---	---	110,000	10
14	Ventura	-b-	---	---	110,000	10
15	San Bernadino	-b-	---	---	110,000	10
16	San Diego	-b-	---	---	110,000	10
17	SF East Bay	-b-	---	---	110,000	10
18	San Jose	-b-	---	---	110,000	10
19	Los Angeles	-b-	---	---	110,000	10
20	Chula Vista	-b-	---	---	110,000	10
21	San Diego	-b-	---	---	110,000	10

<u>Notes:</u>

The 200 million Gallons per year California-ethanol production scenario is assumed to be distributed between 9 plants using approximately 2.7 million BDT per year of biomass. The 9 plants are comprised of: 1, 3 and 4 using forest residues; 7 and 8 using agricultural residues (rice straw + orchard prunings); and any of the five plants between 12 and 21 using urban waste.

b – Assumes that feedstock will be available through existing collection source (e.g. MRF)

BDT - Bone Dry Tons

M Gal/yr – Million Gallons per Year

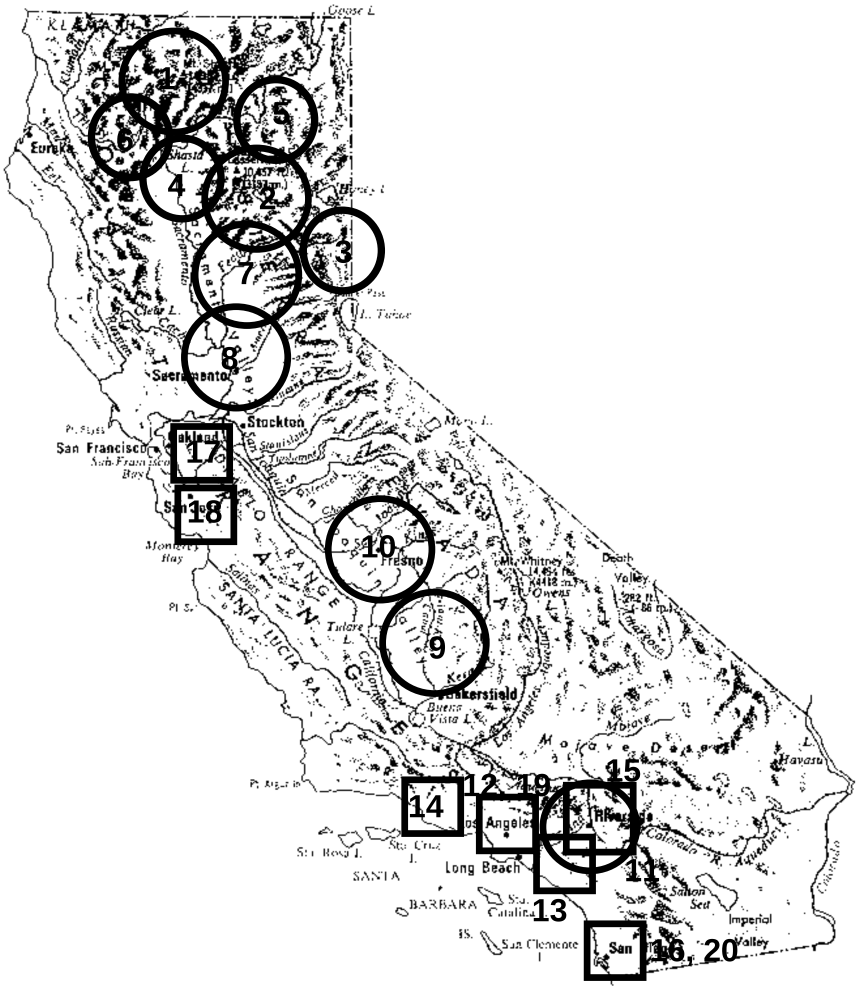


Figure III-4 Assumed Distribution of Biomass Feedstock Supply Regions.
Regions 1- 7, Forest Materials
Regions 8-11, Agricultural Residues
Regions 12-21, Urban Waste
(See Table III-2 for further description of Regions)

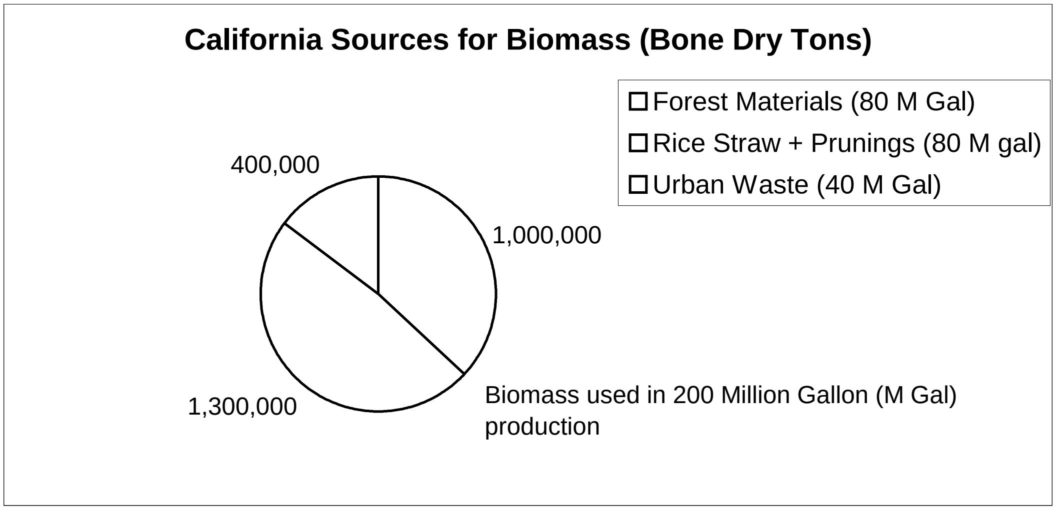


Figure III-5. Biomass Source Distribution in California Ethanol Distribution

III.3 Economic Costs and Benefits of In-State Ethanol Production

Conducting an analysis of California ethanol production and its economic effects on the state economy requires the usage of terminology that differs slightly from colloquial terminology. Specifically, the terms “cost” and “benefit” are often interpreted differently, depending on the audience. For the purposes of this report, an *economic* cost or benefit is meant to be a macroeconomic result, characterizing the total effect of a particular action. A distinct set of micro-level economic activities have been used to distinguish costs and benefits from capital expenditures and economic impacts.

For this work, an “impact” is simply an economic activity that has no positive or negative connotation associated with it. Similarly, “capital expenditure” simply refers to an outlay of money to purchase a capital item. These distinctions are critical, as the cost of a capital item is very different from a cost to the state’s economy. Economic costs and benefits can only be determined after all impacts and expenditures have been considered within the spending “network” of California’s economy. An economic cost or benefit is very different from the sum of all expenditures, because they take into account subsequent consumer spending of increased wages, changes in employment, and relative growth of industrial sectors.

Economists assign very precise meanings to the terms "costs" and "benefits" and it is easy to misuse these terms. In analyzing the costs and benefits of a public policy alternative, the term "cost" refers to the specific investment that has to be made to bring about the desired policy. It is an expenditure that carries a certain amout of risk. The investment itself generates economic repercussions. Economists refer to these repercussions, whether positive or negative, as benefits or impacts.

To illustrate the difference between costs and benefits, consider an example from the financial world: an investor who is calculating the rate of return on a portfolio. The investor's investment is spread over different stocks in a portfolio. Some of the stocks will lose money, whereas other stocks will gain money. The net change in the value of the portfolio is the benefit to the investor. The cost to the investor is the investment itself.

Chapter IV discusses the aggregate effect, or economic costs and benefits, of a California ethanol industry, by analyzing the capital expenditures, plant operation, and employment associated with ethanol production. By accounting for the specific economic activities associated with ethanol production, and inputting these micro-level activities into an economic model, the economy-wide effects, or net economic benefits can be obtained.

III.4 Capital Expenditures

Plant Construction

The capital expenditures involved in ethanol plant construction will play a role in the California economy and must be accounted for in any cost-benefit analysis. In addition to the equipment and material costs, the plants themselves require substantial engineering expertise, land, and permitting. Given the scale of these expenditures, investment, incentives, and financing issues must be addressed not only to ascertain financial feasibility, but to grasp statewide economic impacts of ethanol plant construction.

Identifying appropriate plant sites is an important precursor to plant construction. Once a given site has been located, siting and permitting processes must be addressed to ensure that emissions, traffic, and infrastructure requirements can be fulfilled. While these activities play a limited economic role, they provide an important linkage between government agencies and the plant entrepreneurs.

Each ethanol plant will require building materials for the physical structure that will house the plant equipment. This will result in business for materials suppliers as well as create a need for construction and structural engineering required to erect these facilities. Table III-2 presents the number of plants required for the scenario based on 200 million gallons annual California ethanol production.

Table III-2. CA Ethanol Scenario Summary

CA Ethanol Scenario	Plants	Plant Capacity	Total Capacity
		Million gallons/yr pure ethanol	
Forest Material	2 1	20 40	80
Agricultural Residue	2	40	80
Urban Waste	4	10	40
Totals	**9**		**200**

Once the plant structure is in place, a range of industrial equipment will be installed, including tankage, feedstock processing systems, instrumentation, and control hardware. This equipment will require calibration and certification before production can commence. On completion, testing and limited production can begin. These activities will provide final facility validation and allow plant specific procedures to be developed, as feedstock and climate will vary regionally.

If a viable ethanol industry is to develop in California, investors must determine that this investment has a higher expected return than other investment options. They must also have confidence the economics that make the plant feasible will remain in place for a reasonable period of time. These economics may depend on the guaranteed existence of certain government support programs for plant construction, operation or product markets. Moreover, these financing choices and government incentives influence the macroeconomic impacts of plant construction.

Ethanol Transport/Storage

How is Ethanol Transported and Stored in California?

The majority of U.S. ethanol is currently produced in the Midwest-states of the U.S. Ethanol is currently available in California by rail from production centers in the Midwest or by ship (via the Panama Canal route) from Gulf Coast storage terminals.

Archer Daniels Midland (ADM), the leading producer of fuel ethanol in the U.S. announced, in June 2000, the establishment of an in-state ethanol supply and distribution center at KarebTerminals (formerly Shore) in Crockett, California, to meet the potential demand for ethanol when MTBE is phased out by December, 2002. Transportation of ethanol blends in existing gasoline pipelines poses challenges, however, because of problems related to ethanol's affinity to absorb moisture, phase separation of the ethanol, and the attack on rust spots (especially in the joint areas) which accelerates corrosion in the existing pipeline system.

Many existing gasoline distribution terminals can be expanded to handle ethanol, which requires special handling and delivery. A 1999 survey-report by the Renewable Fuels Association identified 40 terminals across California that indicated the capability to offer ethanol storage and distribution within six months if necessary. Based on the report, it appears that ethanol can be distributed to meet a large portion of the statewide demand within a six month time frame.

Because of its water absorbing and corrosive nature, it is preferable that ethanol is blended with gasoline as near to the final destination terminal as possible. The two most likely blending scenarios with respect to the California ethanol distribution infrastructure are In-Line and Top-Off blending.

<u>In-line blending:</u> The ethanol and gasoline are blended in-line, immediately prior to the meter, before delivery to the vehicle. This method minimizes blending errors, enables better quality control, provides greater reporting ease for program compliance and is currently the preferred method in the states where ethanol-based gasoline is a mature market.

Top-off blending: Ethanol and gasoline would be metered directly into the transport truck and the natural agitation with the loading and transportation processes would blend the ethanol and gasoline.

Existing MTBE tankage may prove to be adequate for ethanol bulk storage. However, modifications such as addition of floating internal roofs for the storage tanks, re-piping to the loading areas, new meters, new blending equipment, etc., will be required. Recent estimates (2) indicate that such modifications would increase the average cost of ethanol blends by 0.1 cents per gallon.

How Would California Produced Ethanol be Stored and Transported?

The locations of the proposed biomass ethanol plants are shown in Figure III-6. Also shown in the same figure are the major California railroad arteries. Ethanol manufactured in plants located in the Los Angeles and San Francisco metro areas can be transported to nearby refineries or gasoline distribution centers by truck for storage and/or blending.

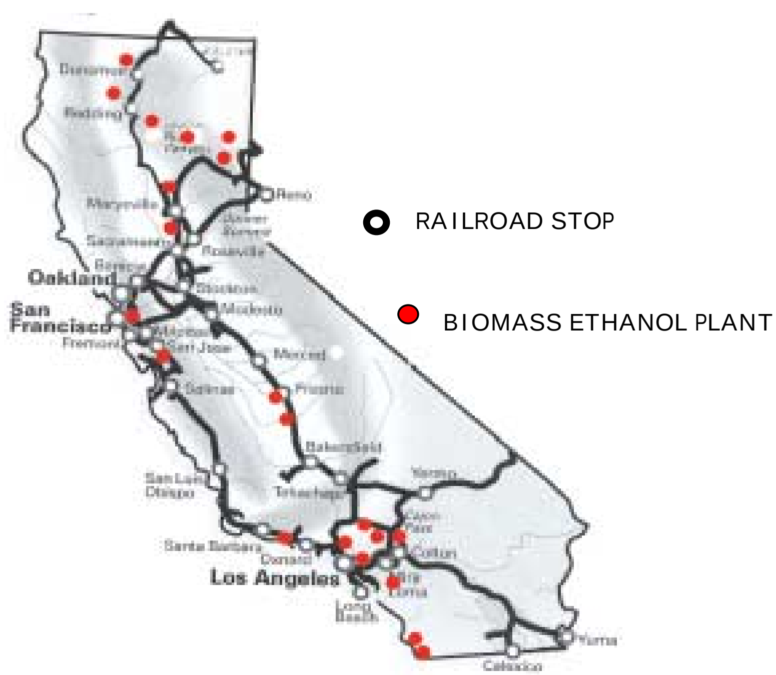


Figure III-6. Biomass-Ethanol Plant Locations and Railroad Network as developed for this report.

Ethanol manufactured in the Northern California plants will have to be transported either to the existing refinery locations in the Los Angeles or San Francisco Bay areas, or existing gasoline storage, blending, and distribution centers in the Sacramento/Central Valley areas. While railroad transportation of ethanol from the plant to the distribution terminal appears to be well suited given the proximity of most of the plants and the terminals to the railroad network, the current thinking is that this mode of transportation is doubtful in the near term and trucks will have to be used. However, most of the forest-based northern California plants will be within 10 miles of the nearest railroad depot and on an average over 100 miles to a major distribution terminal. With large volumes of ethanol being produced, an infrastructure to deliver ethanol from the plant to the railroad depot (less than 10 miles away) and then transportation to the terminal by railcar is not inconceivable. Under the assumption that there will be the stated demand for ethanol, the cost of this infrastructure will be absorbed into the capital cost of the ethanol plant.

An analysis was performed to estimate average transportation distances for ethanol transport from the plant to the nearest terminal (Appendix III-B). The assumptions include primarily pipeline plus railroad transportation in the northern facilities, and truck transport elsewhere. Depending on the plant size, capacity factor and location, the average truck trips per day per plant will vary between 4 and 14. The average truck capacity is assumed to be 7,800 gallons. The one-way distance traveled per truck per day will range between 5 and 100 miles. The length of the pipeline between the plant and the railcar loading point will be between 5 and 10 miles. The average railcar capacity is assumed to be about 29,000 gallons. Depending on the plant size, capacity factor, and location, the one-way distance traveled by the railcar will range from between 50 and 300 miles.

III.5 Ethanol Plant Operation

Ethanol Plant

Ethanol Plant Personnel and Feedstocks

Ethanol plant operation influences many upstream and downstream industries. Plant operations require a host of skills for optimal production. Shift supervisors, equipment operators, engineers, biologists, and a management team are required for plant operation. In addition to operations, each plant requires maintenance personnel and engineering expertise.

The biomass feedstocks that provide the raw materials for ethanol production must be collected, processed, and transported to each conversion facility. This requires collection personnel, equipment operators, truck drivers, and receiving personnel. In addition to raw biomass, ethanol plants require a host of other chemicals as process inputs that depend on the plant configuration. Examples of these inputs include enzymes, acids, gypsum, and diesel fuel. These resources result in revenue for the industrial sectors that produce them and costs to the biomass-to-ethanol plant. Ethanol plants also need water input.

Administering the end product of ethanol entails considerable labor. Ethanol sales in the volume-scales considered within this report would require a full-time sales staff as well as marketing and finance personnel.

By-Products of Ethanol Production

Lignin is a component of lignocellulosic biomass, which generally passes through the biomass to ethanol conversion system unchanged. The energy value of lignin, depending on the biomass source, ranges from 9,000 Btu/lb to 12,000 Btu/lb. Lignin from the biomass to ethanol process can also be used as a combustion fuel. About 4 tons of lignin is produced for every million gallons of ethanol produced in the biomass-ethanol conversion process. Lignin, depending on the quality, can also be processed into high-value, specialty products such as plasticizers, extractives, electrically conducting polymers, or phenolic-resins which may be used as glues or binders in production of plywood and fiberboard. In this study, only the economics of lignin as a fuel are included.

Ash is a significant component of all biomass. Some sources such as rice straw not only have a high ash content but also contain sodium silicates that can lead to disposal problems. For example, sodium silicate in the lignin may preclude it as a combustion fuel due to severe combustor slagging problems that can result from using the lignin as a fuel. Silica from rice straw can be separated as a product with special properties and can be a value added product. In general, disposal of ash is not a critical concern. Ash from some sources can be used as a filler in cement and concrete. However, proper disposal of ash will involve analysis for hazardous trace metals. The EPA regulates very low concentrations of certain hazardous trace metals.

Some sources of lignocellulosic biomass can contain as much as fifteen percent protein based on a dry weight. A well-balanced plant protein has approximately a $0.75/lb commercial value.

The concept of a biomass ethanol refinery integrated with a biomass power plant is illustrated in Figure III-7.

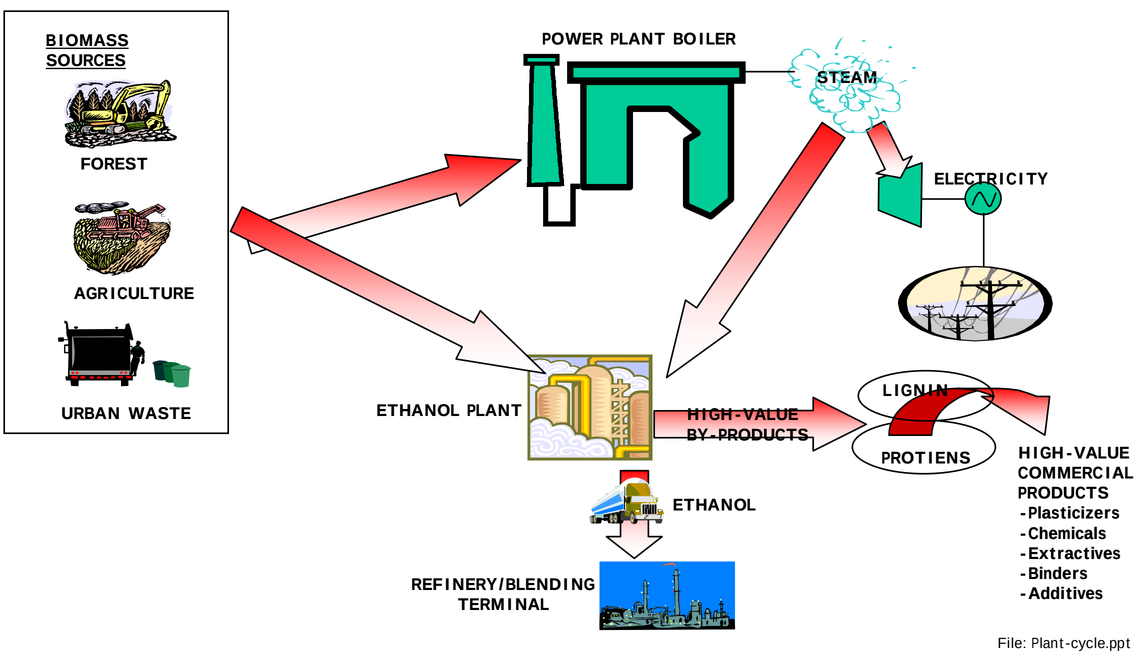


Figure III-7. Integrated Biomass Ethanol Refinery

Feedstock Availability/Sources

The location, area and quantity of feedstock avialable from each of the three source types was described earlier in Chapter III. The following presents a discussion on the availability of the feedstock for each source-type.

Forest Material Feedstock Availability

Excess woody materials are available in California forests, according to an extensive study by the Quincy Library Group (1997). This material is available in the form of slash left on the ground after commercial timber harvesting, pre-commercial selective thinning, and woodmill residues. A California Energy Commission biomass resource assessment estimated that over 8 million bone dry tons of forest slash and thinnings are available per year (CEC 1999). In addition, an assessment by the Quincy Library Group indicated that 700,000-1.1 million bone dry tons of biomass per year could be thinned and gathered from timber harvesting slash in three northern California national forests (QLG 1997).

Based on the Quincy Library Group study results, the baseline for this study assumes that enough biomass is available from forests to meet a demand of 200 million gallons per year. Some forest ecologists believe this availability is too high due to potential damage to forest ecosystems (Hanson). As environmental impacts are further assessed, the estimated portion of feedstock from forest materials may be reduced and shifted to other feedstocks.

At this time, many sources report that biomass is available through thinning operations for several reasons. One reason is that many forests have become extremely dense due to years of fire suppression. As a result, biomass can be removed in order to restore the health of the forest and reduce fire risk. Also, diseased trees and invasive species can be removed to prevent their spread. See Section VI for a discussion of forest health, including effects of forest fires.

In addition to thinning, the California ethanol demand of approximately one million bone dry tons can be met with a slash and woodmill residue. Slash treatment and forest thinning operations will conform to California's Forest Practice Rules. This will focus selective removal on the least environmentally vulnerable sites and forests (see Section VI for further discussion). In order to meet the demand for ethanol feedstock, thinning rotations need not be greater than once per decade for any forest unit. In addition, hand thinning may be necessary to prevent ecological damage.

The recently issued Rules for Roadless Area Conservation in National Forests is not expected to significantly impede the harvesting of biomass for use in ethanol production, for several reasons. First, only 31 percent of the National Forest System (NFS) lands are roadless and thus affected by the new rules, and these forests collectively represent only about 0.5% of the total US timber harvest. Furthermore, biomass removals as part of forest management will not be affected on NFS lands for which timber contracts already exist, since these contracts are exempt from the rules. Secondly, biomass removals for ethanol production are unlikely to be economically justifiable in roadless areas due to the planning, permitting and implementation costs of logging road construction and the required mitigation of adverse impacts from such activities; even some NFS lands with logging roads may be too far from ethanol production facilities to be economically feasible as sources of biomass. Finally, the new rules contain provisions for new road building where needed to preserve or enhance the forest ecosystem, which arguably will include biomass removals that are needed for the dual purposes of preventing ecological damages from forest fires and diseases, while preventing property damage. Thus, the new rules for ecosystem conservation in roadless areas of the NFS can be viewed as posing no more of a restriction on the proposed harvesting of biomass for ethanol production than do California's existing Forest Practice Rules, along with other state and federal environmental regulations that require forestry operations to be conducted (and mitigated) in an ecologically sensitive manner.

Although the Rules for Roadless Area Conservation in National Forests may not affect biomass availability, many ecologists and environmental organizations are concerned about the removal of wood from forests, especially public lands. In an effort not to duplicate discussion of the environmental issues, potentially negative effects are discussed in Chapter VI. However, it should be stated here that although a formal environmental impact assessment would be necessary to determine site specific impacts, in general, it should be possible to remove biomass beneficially by using appropriate methods in least sensitive areas. Nevertheless, as stated above, availability may be limited if there is opposition to commercial use of forest material from public lands or if studies show unavoidable degradation to ecosystems. As a result, a forum that includes many stakeholders must be established to determine who has the authority to choose areas to be harvested, the manner in which the material is removed, and which organizations will oversee and monitor the forest health.

One area that will not be available for biomass harvesting is chaparral vegetation, which consists mostly of scrubby, slow-growing, evergreen shrubs. Fire promotes new growth and supports native chaparral flora while eliminating invasive, introduced plant species that are not fire-adapted. Biomass removal thus would undermine the food chain and put these fragile habitats at risk of being displaced by invasive species (see Appendix VI-A for more information about environmental effects). In addition, the productivity of chaparral is too low to support sustainable yield harvesting of biomass. The chaparral biomass is also unattractive from both an economic and processing perspective, since chaparral plants contain resins and chemicals that are undesirable for ethanol production.

Rice Straw Quantities and Location in California

Rice straw is a potential feedstock for California ethanol production. In all, there are over 700,000 acres of rice grown each year, mostly in Northern California (Paul Buttner, California Air Resources Board). Each acre produces between 1-2.5 tons of rice straw (Buttner; Ken Collins, Rice Straw Cooperative). In years prior, rice straw was burned by farmers because this disposal method offered them two advantages: the disposal costs were very inexpensive at about $2/acre, and burning was an effective method for controlling rice diseases. Over the years, however, rice farmers have been forced to burn increasingly less of their rice straw due to concerns about air quality. Under the current law, rice farmers are now restricted to burning the rice straw from the lesser of 25 percent of their own acreage or 125,000 state aggregate acres. Starting in 2001, they will be able to burn up to this amount only if they can show evidence of disease requiring that extent of burning. Rice farmers are now faced with two, more expensive alternatives for disposing of their rice straw. For about $40/acre, the straw can be tilled back into the soil (Buttner; Collins). But the problem with this disposal method, other than its increased cost as compared to burning, is that it does not help to control disease. The other option is to cut and bale the rice straw at a cost of about $60-$80/acre, or $20-$80/BDT (Buttner; Collins). It is this latter option that may serve as a basis to provide rice straw as a feedstock for ethanol production in California (see Figure III-8).

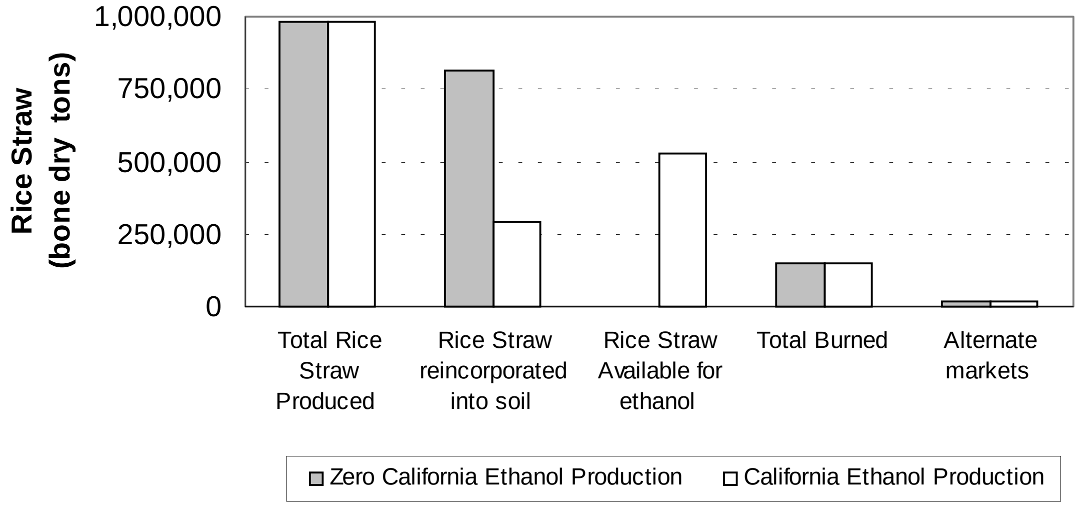


Figure III-8. Rice Straw Disposal Methods with and without Ethanol Industry

Feedstock Cost

As of 2001, the law will permit rice farmers to burn up to 25 percent of their acreage that is diseased. However, rice straw suppliers predict that a smaller percentage will be burned due to the practical limitations imposed on farmers by “no burn” days and the pressure from regulators to burn less than the above safe harbor maximum. Accordingly, rice straw suppliers estimate that there will be a total of about 540,000 BDT of rice straw available each year for baling (Collins). The remainder of the rice straw that is not burned or baled will be tilled into the soil. The selling price of baled rice straw likely will range from about $40-$55/BDT, which likely would include the cost of delivering the bales to within a 25 mile radius of the source crop (Collins). If the demand for baled straw increased and commercial balers became more involved in the industry, the price of baled straw could fall to as low as $30/BDT as production costs drop. The price of baled straw could thus actually decrease with an increase in demand because economies of scale would permit the utilization of more cost effective methods of baling.

Absence of Current Demand for Alternative Uses

While there is a large supply of rice that could be baled in California, there is currently a very small market demand for this commodity. Rice straw suppliers estimate that, in recent years, only about 2 percent of California’s total rice acreage was baled and sold. The remaining 98% of the statewide acreage was either burned or tilled back into the soil. When the demand for baled straw lags behind the supply in this manner, rice farmers often react by tilling the straw into their soil in subsequent years to save costs, instead of cutting and baling straw that cannot be sold due to the high costs of baling per acre. To date, the potential markets for baled rice straw include animal feed, animal bedding, erosion control, building products, and ethanol production. The ethanol plant proposed to be built in Gridley would likely purchase about 75,000 BDT of rice straw per year. But it most likely would do so at purchase prices that would not cover the supplier's cutting and baling costs.

Current Demand Subsidies

A law was recently passed in California for the purpose of stimulating demand for rice straw. Assembly Bill 2514, as originally drafted, provided a $20 per ton tax credit (not specified wet or dry basis) to rice straw end users (such as ethanol plants) with a statewide aggregate limit of $10 million. However, when Governor Davis signed the bill into law, the tax credit had been altered to a grant program with a $2 million limit over a three-year period. Rice straw suppliers are of the opinion that the original version of the bill is closer to the kind of government sponsored, economic jump-start that the rice straw end-user industry will need.

Steady Feedstock Supply Availability

Given the above considerations, it appears there will be about 500,000 BDT available each year in California for ethanol production. The cost per dry ton of this feedstock should range from about $55/BDT at the high end and about $30/BDT at the low end if economies of scale begin to apply. Additional tons could become available beyond the aforementioned 500,000 figure, if ethanol plants are willing to pay rice farmers enough for the feedstock to make cutting and baling cost competitive with tilling the straw back into the soil. Given that the cost of cutting and baling the straw is about $60-$80 acre, or $20-$80/BDT without economies of scale, it is possible that straw supply could be increased to replace tilling for about this same price per dry ton of baled rice straw.

Greater Subsidies Needed To Increase Supply

In conclusion, the economic feasibility of ethanol production using rice straw feedstock would require, most likely, the location of ethanol plants within about 25 miles of rice farms. Also, these plants would have to purchase the feedstock for around $30-$40/BDT; and greater distances require higher purchase prices. Further, an ethanol plant would need an alternate source of feedstock for much of the year since rice straw is harvested only seasonally. Ethanol plants tend to require a negative cost feedstock. Further barriers to rice straw-based ethanol plants include commercial realization of the conversion technology and the high silica content (~13 %) of rice straw. The extraction of silica in a special amorphous form from the rice straw will enable it to be sold as a value-added product. Otherwise, the silica has to be disposed with other generated waste. In general, in absence of the provision of feedstock subsidies even larger than those envisioned by the original version Assembly Bill 2514, it is unlikely that rice straw will be an economically viable feedstock choice on its own. However, when used with other agricultural residue feedstocks in ethanol plants located nearby, this study assumes that rice straw can be used for ethanol production.

Other Agricultural Residues

A significant portion of biomass for ethanol production is other agricultural residues. This includes mainly orchard prunings, but other vine or row crop residues are possible feedstocks. The agricultural residues considered for ethanol production in this study are normally landfilled or burned. In an effort to divert material from landfills and reduce open burning, which is a major contributor to agricultural pollution, 700,000 bone dry tons of non-rice straw residues can be collected and transported to ethanol production facilities to meet the 200 million gallon demand. This availability is based upon the volume of agricultural residue used in biomass power plants at Woodland and Delano. Beyond, 200 million gallons, it appears to be a stretch to obtain these types of agricultural residues.

In addition to residues, feedstock may be available from crops experiencing a glut in supply. For example, sugar beets, corn, or other crops can be used for feedstock when the price is low. This study did not examine the economics of these feedstocks.

Urban Waste

Impact of Diversion Law on Ethanol Feedstocks

AB 939 is a law in California that requires each municipality to divert 50 percent of their municipal solid waste (MSW) from disposal in landfills into recycling or other diversion methods by 2000. Under the present language of the law, municipalities are strongly discouraged from attempting to meet this quota by diverting MSW to ethanol production instead of diverting it to paper mills. The reason is that the law distinguishes between diversion methods that are considered "recycling," such as making paper products from other paper products, and those that are considered "transformation," as when waste paper or other organic material is turned into ethanol.

Current Law

As AB 939 is currently written, municipalities are generally discouraged from diverting waste paper products that are capable of being recycled into transformation processes like ethanol production. These activities are discouraged because only 10 percent of the diversion credit may be obtained by transformation processes. That being the case, if a given municipality is assisted in meeting its 50 percent diversion quota by diverting some of its MSW to recycling, it would not likely be able to continue to meet its quota if the same MSW was instead diverted to ethanol production.

Even so, AB 939 as currently written is not likely to affect the availability of MSW feedstock for ethanol production in California. This is because the types of MSW that are capable of being recycled and thus eligible for full diversion credit under the law are usually too expensive to be ethanol feedstocks. Conversely, the types of MSW that are not generally recycled (and are thus landfilled) and have the lowest value tend to be well suited for ethanol production. These suitable MSW feedstocks include items such as low-grade waste paper and other organic waste. The only scenario in which AB939 might affect MSW ethanol feedstock availability is in the unlikely event that the selling price of ethanol was to become so high that ethanol producers could afford to compete with MSW recyclers for their feedstock.

In conclusion, the current transformation discounting provisions of AB939 would not have a significant impact on the economic feasibility of producing ethanol from MSW feedstocks. The feedstocks to be used for ethanol usually are not diverted to recycling. And since these feedstocks are placed into landfills, the economic feasibility of using them for ethanol production will depend on the cost advantages, if any, that ethanol production of these feedstocks will offer as compared to placing them in landfills.

Impact of Changes to Current Law

If AB 939 was amended to provide equal diversion credit for both transformation and recycling activities, there would no longer be any diversion quota inhibition for diverting recyclable MSW to transformation activities like ethanol production. However, although ethanol production then would be entitled to full diversion credit, ethanol producers would still not likely compete for recyclable MSW feedstocks, due to their high cost. As a result, even if AB 939 was so amended, it probably would not affect ethanol producers' use of recyclable MSW feedstocks such as higher grades of waste paper or urban wood waste.

However, if AB 939 was amended, residual ethanol diversion could be increased or encouraged in the following way: Some jurisdictions in California now struggle or fail to meet their diversion quotas. Some of these jurisdictions could be assisted in meeting their quota by diverting their MRF waste paper residual. If diversion to ethanol production was the lowest cost alternative available for meeting their quota, then ethanol diversion of MRF residual might become an attractive diversion option. In this situation, residual ethanol diversion could be adopted by some municipalities as the most cost effective method for meeting their quotas, even if such ethanol diversion would not have been cost effective on strictly economic grounds. Amendments to AB 939 could therefore help to boost and encourage an ethanol from waste paper industry in California in those situations where it would be more cost effective than other means of waste diversion.

Waste Paper as Feedstock

Due to its high cellulose content and large volume of availability, one of the potential feedstocks for ethanol production in California is waste paper products (WP). WP includes a wide variety of materials such as white ledger paper, newspaper, phone books, plastic coated paper and items such as cardboard pizza boxes that have been exposed to or contaminated by food, beverages, or grease. Some of the WP of these different types is recycled by paper mills or by other recycling processes, and some of it is placed into landfills.

Recyclable Paper Grades are not Feasible

As a general matter, the same types of waste paper products considered capable of recycling tend to command prices per ton on the recycling market that are above that with which the ethanol industry could compete for its feedstocks. Mixed paper, for example, one of the lower grades of paper, was selling for $50-60/ton at the time of this publication. Ethanol producers could only afford feedstocks if the selling price of ethanol reached approximately $3/gallon, which is about twice the selling price predicted in this study. Many other grades of recyclable waste paper, such as white ledger paper, command even higher prices per ton and are thus less likely to be suitable feedstocks for ethanol production.

Non-Recyclable Paper Grades are Feasible

There are grades of waste paper that are considered sub-standard for paper recycling purposes but which are suitable for ethanol production. These types of waste paper are often disposed of by materials recovery facilities (MRFs) after they are separated and sorted from the recyclable grades of waste paper. These lowest grades of waste paper are generally referred to as “MRF waste paper residual” and are disposed of in landfills. Since this residual would most likely be disposed of in a landfill if it were not diverted to ethanol production, ethanol diversion of MRF residual does not pose any of the AB939 quota disadvantages that are involved with recyclable waste paper grades.

Disposal Cost Savings with Ethanol Diversion

Once MRF waste paper residual is sorted at a MRF, a municipality usually incurs two additional costs to dispose of it into a landfill: first, the cost of transporting the residual to a landfill, and, second, the cost of depositing the residual into a landfill (otherwise known as a landfill “tipping” fee). Statewide, about 10 percent of all the waste placed in landfills in California consists of such post MRF waste paper residual (over 3.5 million wet tons/year).

Rather than disposing of MRF residual in a landfill, a municipality could choose to conduct some additional sorting of the MRF residual in order to better sort and prepare it as an ethanol feedstock. After such sorting, the average municipality could then pay a collocated ethanol plant to accept the sorted residual and still incur lower residual disposal costs than by transporting and placing the residual into a landfill. By diverting its residual to ethanol production, a municipality could reduce its waste paper disposal costs. For further discussion, see Appendix R.

Insufficient Feedstock Quantity: Supplementation Necessary

While the diversion of MRF waste paper residual to ethanol production could provide cost savings to municipalities on a disposal cost per ton basis, the minimum sized ethanol plant of 10 million gallons per year would not likely obtain a sufficient amount of this feedstock from even larger sized MRFs. The other potential sources of supplemental organic urban waste materials can generally be divided into two types: those for which there is already an established market demand and those for which there is not. Ethanol production will most likely have to be based on the latter. Organic feedstocks for which there is already an established market demand include yard waste, tree trimmings, and urban wood waste.

Yard Waste/Tree Trimmings Not a Feasible Supplement

Organic feedstocks such as yard waste and tree trimmings would not be feasible ethanol feedstocks because they are generally utilized by landfills for what is called “alternative daily cover” (ADC), or as a substitute for covering the landfill waste with dirt layers. Materials that are used as ADC are counted toward the 50 percent diversion requirements of AB939. Landfills also have a need for these materials to avoid the cost of bringing in actual dirt. Accordingly, landfills usually offer a substantially lower tipping fee for ADC materials, since they want to encourage their supply. And under the current law, any diversion of them to ethanol production would interfere with a landfill's 50 percent diversion quota. For these reasons, ethanol plants would not be able to compete for these types of organic feedstock to supplement MRF paper residual.

Urban Wood Waste Not a Feasible Supplement

Urban wood waste includes items such as pallets, two-by-fours, and construction wood scraps. These items are valued at about $50/ton when they are used to make particle wood and other construction related products. Because of its established market and high dollar value, urban wood waste would not be a feasible feedstock supplement for ethanol production.

Feasible Supplements: Landfilled Organic Waste

Organic materials for which there is not an established market and which are currently landfilled could serve as a feasible feedstock supplement for ethanol plants. These materials include food, textiles, and other mixed organic waste. Statewide, these types of organic materials comprise close to 30 percent of all the waste that is currently placed into landfills in California. Since these types of materials are not considered recyclable, they are usually not placed with commingled or recyclables. As a result, they are not sorted by a MRF. Instead, these materials are collected as trash and sent to transfer stations for subsequent transport to a landfill, as depicted by the black arrow on the left side of the flow diagram in Figure III-9. It is possible that a low cost form of sorting could be done at transfer stations in order to separate organic types of waste from inorganic (concrete, re-bars, etc.), and that the resulting organic mix could then be diverted to a collocated ethanol plan. This diversion is shown as the movement of dashed-gray arrows in Figure III-9. Since transfer stations of this sort are often collocated with MRFs, this organic feedstock could thus be used to supplement a collocated ethanol plant's use of paper residual from a MRF, which is shown in gray on the right side of Figure III-9.

<u>Collocation of Ethanol Plant with Transfer Station/Material Recovery Facility</u>

Diversion of MRF paper residual and organic materials from landfills to ethanol production would result in cost savings in cases where the combined cost of the tipping fee charged by an ethanol plant and the cost of sorting ethanol feedstock is less than the cost of transporting and tipping to a landfill. Ethanol production that is collocated to transfer stations/MRFs can offer municipalities comparative cost savings for MSW disposal, as the distance from the landfill to the transfer station/MRF increases and as the landfill tipping fees become higher. One key savings that an ethanol plant can offer is based then on its collocation to its feeding transfer station/MRF in order to avoid the costs associated with transporting MSW from these facilities to a landfill.

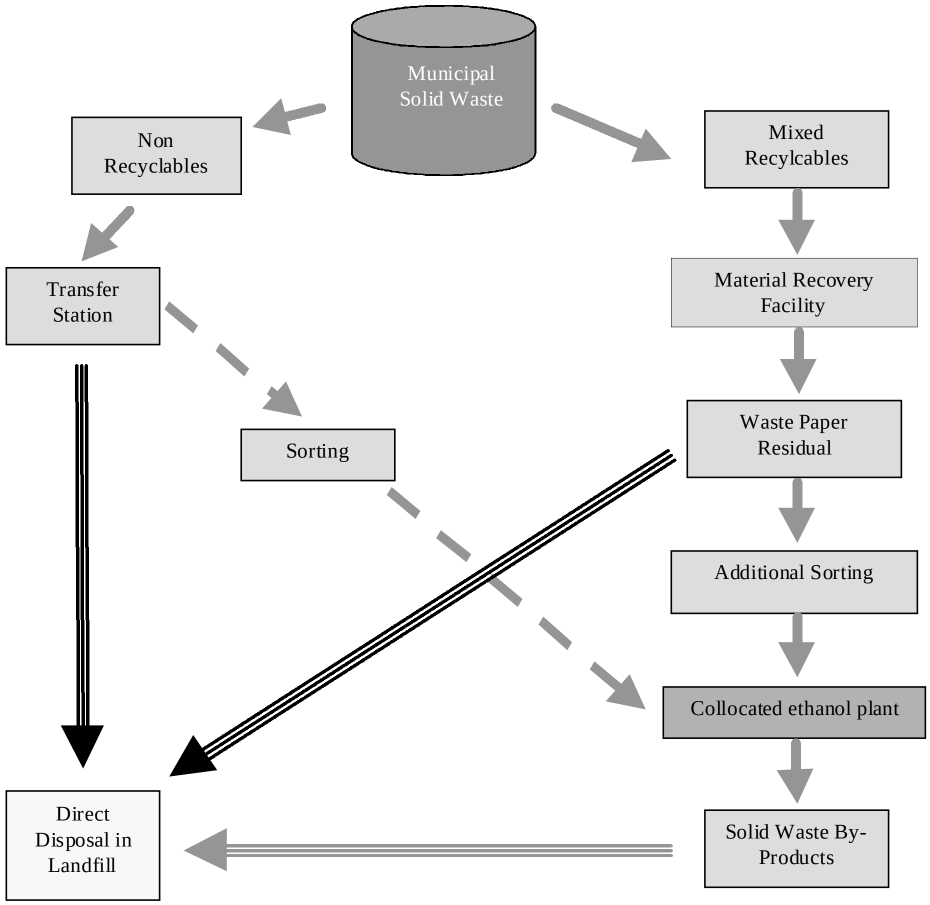


Figure III-9. Fate and movement of waste paper and other materials with collocated ethanol plant

<u>Quantities of Diverted Landfill Feedstock Supply Available</u>

Finally, the most feasible, cost effective scenario for a collocated ethanol plant that uses landfill diverted feedstocks would rely on a mixture of feedstocks including MRF waste paper residual and organic materials sorted from a transfer station's total waste stream. With this combination of feedstocks, a large transfer station/MRF (such as one that processed around 3,000 tons of the total waste stream per day) would provide the necessary three to four hundred wet tons of feedstock per day that a 10 million gallon/year plant requires.

Feedstock Collection

Doesn't California Already Have a Biomass Collection Industry?

California has a biomass collection industry that supplies forest residues and agricultural wastes to biomass-based power plants. Ethanol production would likely be collocated with existing biomass-based power plants. Up to 6 million dry tons per year of biomass have been collected for power production in California. These feedstocks consisted primarily of lumber mill waste, forest material, urban wood waste and agricultural residue. Other than urban wood waste, these feedstocks would be the primary materials used in an ethanol industry as shown in Table III-3. Urban wastes such as waste paper are already collected but not used for energy production. The collection of these materials is discussed in the following section. Figure III-10 presents the California power-plant biomass fuel supply curve based on data between the years 1986 and 2000.

Table III-3. Total Feedstocks For Energy Conversion

Feedstock	Zero CA Ethanol Scenario (BDT)	CA Ethanol Scenario (BDT)
Forest material	700,000	1,00,000
Agricultural Residue	400,000	1,300,000
Urban Waste	-a-	400,000
Total	1,100,000	2,700,000
a – not used in energy production		

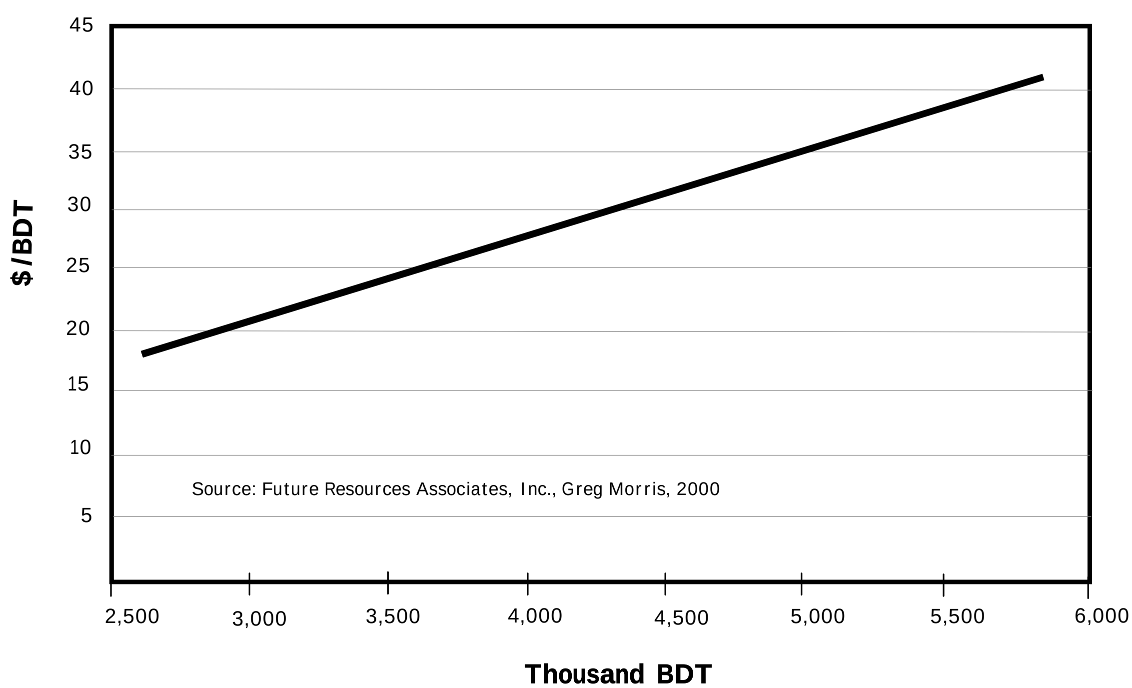


Figure III-10. California Power-Plant Biomass Fuel Supply Curve, 1986-2000

Supplying forest residue biomass fuel involves harvesting, collection, processing, and transportation. Biomass collection requires movement of forest residue to a landing site in or near the forest by skidding, cable yarding, or some other method. At the landing site, the biomass is processed for the plant by chipping. The biomass is blown directly into a chip van that loads the chipper. An average chipper can process about 15 BDT/hour and produce one half-inch size chips. The processed biomass is then transported to the power plant site. Hauling trucks have a typical capacity of 13 BDT/truck.

Agricultural waste such as rice straw is transported in bales. Conventional equipment such as hydraulic lifts, fork lifts and equipment specifically designed for handling baled straw are used for loading and unloading trucks. Typically, straw bales are hauled by conventional trucks and flatbed trailer rigs. Trucks and rigs carrying small bales will carry 10 to 15 tons per load, whereas trucks carrying large bales will carry 20 to 25 tons per load.

Figures III-11 through III-14 show examples of typical biomass collection and processing equipment.

Figure III-11. Cable-yarding crane

Figure III-12. Wood chipper

Figure III-13. Processed Forest Residue Biomass Delivery to Plant

Figure III-14. Straw Baler

Feedstock Collection Economic Impacts

Under one scenario, the production of 200 million gal/year of ethanol in California will require approximately 2.71 Million BDT of biomass made up from various sources. The collection of this feedstock has significant impact on a number of factors. Some key factors are elaborated below:

- In the above scenario, nearly 1.2 million BDT/yr of forest residue will be used. Within the same control area, if no ethanol is produced, only about 100,000 BDT/yr of biomass is used. The number of equipment for the harvesting, collection, processing and supply of biomass will increase significantly with ethanol production.

- There will be an increase in employment from the feedstock production for ethanol. The average employment income value is 18 $/BDT which has to be paid by the employer.

- The benefits of forest fire risk reduction range between 3 and 36 $/BDT of material removed. Although feedstock collection will produce many other environmental effects, the accounting of economic costs and benefits used in this study do not include effects unless they have the types of impacts discussed earlier in this section (eg. changes to capital, employment, personal income). Unfortunately, there is great difficulty in relating environmental values to these economic impacts (eg. changes to air quality, soil quality, habitat). As a result, they are dealt with separately in Chapter VI.

- The increased use of biomass for ethanol production could have the potential impact of drawing away the biomass currently being utilized by other industries such as the biomass power industry, the wood-waste by-product industry and the recycle paper industry.

Feedstock Transport

Each type of feedstock used for ethanol production has unique transportation requirements that, in some cases, may be comparable to non-ethanol alternatives. Collecting feedstocks and transportation to production facilities are labor intensive activities. This economic activity is a positive direct impact.

- Forest Slash and Thinning: requires hauling by truck from the feedstock source to nearby ethanol production facilities. Although ethanol by-product lignin is used for electric power, some ash remains and must be transported off the production site.

- Lumbermill Waste: For ethanol facilities collocated with a lumbermill, additional transportation will not be required.

- Agricultural Residue and Rice Straw: requires hauling by truck to nearby ethanol production facilities located in the California Central Valley. Since rice straw by-products are not suitable for burning in a power plant, they must be transported off-site.

- Urban Waste: hauling distances and trips per day from material recovery facilities (MRFs) to ethanol production facilities are, on average, comparable to distances from MRFs to landfills. Some ethanol production is expected to be collocated with MRFs but transportation is necessary for feedstock from nearby off-site MRFs. Ethanol by-products must be transported to the landfill since they are not permitted to be burned in urban areas.

Table III-4 summarizes feedstock truck transport activities related to the operation of the ethanol plants.

Table III-4. Truck Activities per Million Gallons of Biomass Ethanol Produced

Activity	Forest Slashing/Thinning	Urban Waste	Agricultural Residue
Truck Trips /Million Gal	600	525	1,100
One-way Miles /Million Gal	30-60	20	20
# of New trucks /Million Gal/yr	0.6 - 1	0.3	0.5

Feedstock transport, as well as plant construction, plant operation, and biomass collection, would provide economic benefits to the State. The following chapter explains how economic costs and benefits are analyzed and assesses the total economic impacts of an ethanol production industry on California.

References

Quincy Library Group et al. *Northeastern California Ethanol Manufacturing Feasibility Study*. November, 1997.

CHAPTER IV

ECONOMIC COSTS AND BENEFITS OF IN-STATE ETHANOL PRODUCTION

IV. Economic Costs and Benefits of In-State Ethanol Production

The previous chapter identifies the categories of impacts that California ethanol production would have on the State. This chapter attempts to explain the methodology by which these impacts were studied in determining the total economic costs and benefits of an ethanol industry in California. Direct, indirect, and induced economic impacts are defined and calculated. In addition, the effects of capital investment in plant construction, operation, and maintenance on economic output, personal income, and employment are determined. Finally, this chapter suggests ways the state could foster ethanol production in California.

IV.1 How are Economic Costs and Benefits Analyzed?

The economic analysis of a public policy decision, such as state support for a fuel ethanol industry, follows a different set of rules then those that might be followed by an individual investor. The investor is interested only in the return on the capitol invested and the certainty with which that return can be predicted. The investor will reject a potential investment that fails to meet a predetermined rate of return, often referred to as the hurdle rate. This is purely a financial analysis that weighs the cost of producing a product with the expected income from selling the product. In public policy decision analysis, the analyst considers a greatly expanded set of impacts including those on the community, the regional and state economies, government operations and other policy goals such as income equity, economic development, energy efficiency, energy independence, etc.

The economic analysis conducted in this study is of a public policy that would have the state providing some financial support to the development of a California based fuel ethanol industry. As such, the prospective from which this analysis is conducted is that of state government evaluating the commitment of state resources, the cost of the policy, against the potential benefits to individuals, organizations and the economy of the state. The task is to calculate the economic impacts between the base case and selected alternatives. These impacts include the direct, indirect and induced economic consequences of a potential state fuel ethanol industry.

Direct impacts are the economic activities occurring at the plant site or other related site such as the purchase of capital equipment and the process inputs to produce ethanol. Indirect impacts occur in other sectors of the economy that experience changes in output as a result of the ethanol production such as the steel industry that would supply steel for the production of the capitol equipment. Induced impacts occur as the direct and indirect expenditures trigger a chain reaction of spending through the economy. Any of these impacts may occur within or outside of California.

The costs and benefits related to the investment of government resources in a fuel ethanol industry will occur over time. Some direct impacts, such as plant construction, occur immediately while others such as plant maintenance will be spread over the life of the plant. Depending on the nature of the government support, the government expenditures will have different patterns. Construction subsidies would occur immediately while price supports would follow production. Benefits will have distinct patterns as well, depending on assumptions about oil prices, ethanol imports etc. A dollar spent today does not have the same value as a dollar spent a decade from now. Economists call this the time value of money. The time value of money requires analysts confronted with cost or benefits occurring in different periods to adjust the estimates to a common period prior to the evaluation of benefit cost ratios of program alternatives.

Thus, in order to compare costs and benefits of alternative ethanol fuel industry support programs, it is necessary to bring the estimated stream of costs and benefits to a present value. Then, present value benefit cost ratios can be calculated for program comparison. Programs that exhibit the highest benefit cost ratios provide the most benefits per dollar of expenditure. Programs with the largest net benefits offer the largest impact on the economy.

The impact on the State of California is measured in terms of the following economic variables:

- Gross output
- Employment
- Personal income
- Value added

Gross output reflects the total quantity of goods and services produced in the state. This figure includes inter-industry sales and therefore exceeds the value of goods and services sold for final consumptionValue added is a measure of economic output that eliminates inter-industry sales and therefore reflects the amount of output added by each industry. Total value added in the state corresponds to Gross State Product (GSP), or the value of goods and services sold for final consumption. Employment and personal income correspond to the jobs and salaries associated with a California ethanol production industry.

IV.2 Ethanol Production Impacts

There are several impacts that result from a California ethanol industry. For the purpose of this report, these impacts are divided into four categories: economic, employment, energy, and environmental. While these topics are addressed in detail in Chapters III and VI, a brief discussion of each will be given here to provide an industry overview. It is worth noting here that the term “impact” is used with neither positive nor negative implications. Because of the coupling that exists between industrial sectors, the use of a given resource may or may not have a positive economic effect. Many of the direct, in-direct, and induced impacts detailed in this section stem from the linkages between industrial sectors. The economy-wide effect of consuming a resource is dependent upon the conditions in all related sectors. As a result, it is difficult to assess whether a given economic activity is either positive or negative. The implications of each economic activity are discussed further in Section IV.4 below.

Economic and Employment Impacts

Economic impacts, as defined within this study, include ethanol plant construction, plant operation, displaced ethanol imports due to domestic production, and tax revenues. Plant construction effects include employment for the construction industry, equipment purchase, and material purchase. Employment impacts include plant operation/maintenance, biomass feedstock collection, ethanol transportation, and ethanol sales/marketing. Both employment and economic impacts are examined herein.

Energy Impacts

The scenarios in this study are based on ethanol production technologies analyzed in the Energy Commission's 1999 report. This study focuses on plants that would operate on forest material, agricultural residue, and urban waste. Biomass to ethanol plants are collocated with several biomass power facilities. Consequently, some ethanol plants will have electricity as a by-product, which can be redistributed to the power grid. Net electricity to the grid will be reduced if the biomass power facilities were to remain operational in the absence of ethanol production. This situation, which reflects high power prices in 2001, is the baseline scenario for this study. The energy impacts of collocated power plants are discussed in Chapter V, while the economic costs and benefits are discussed herein.

Environmental Impacts

There are significant environmental implications of introducing a biomass-based ethanol industry. Several of the biomass feedstocks, such as rice straw and forest slash, are currently incinerated to simplify disposal or to provide forest-fire protection. Since these feedstocks would be consumed by ethanol production facilities, airborne emissions would be decreased as open-field burning is avoided with the introduction of biomass-to-ethanol plants. The details of the environmental impacts are covered in Chapter VI.

IV.3 Economic Impact Assessment Methodology

The methodology used to evaluate the benefits and costs of an ethanol production industry consists of three main steps. First, the inputs required to develop the ethanol production industry were estimated. This entailed defining and measuring the capital and operating costs, which were then used in conjunction with an economic impact (Input-Output) model to estimate the total repercussions on the economy. Next, the associated impacts were forecast over a specific time horizon. Finally, the net present value of the cost and benefit streams were used to estimate the benefit cost ratios for each alternative.

Types of Economic Impacts

The economic impacts of the fuel ethanol industry are measured by the cumulative flow of spending that originates at the ethanol plant level and eventually works its way throughout the local, regional and perhaps national economies. The investment in ethanol plants creates demand for goods and services at the plant, in supply industries that support the construction and operation of the plant and in the goods and services purchased with the earned income associated with the entire ethanol production supply chain.

Firms or individuals in a market economy are assumed to respond to price changes. Consequently, economic stimuli can generate a variety of impacts. Examples of these impacts include: shifts in supply due to increases in productivity; changes in demand due to price changes; output growth due to improvements in regional competitiveness; shifts in the composition of factor inputs due to changes in relative input prices; increased demand for factor inputs due to output growth; and increased consumer spending due to improvements in earnings.

Tools for Measuring Inputs

General equilibrium analysis is the preferred way of estimating all of the different types of effects. Computable General Equilibrium (CGE) models have been developed for this purpose and attempt to look at all adjustments simultaneously. Unfortunately, they are extremely complicated and usually prohibitively expensive. Furthermore, the impacts associated with an ethanol industry are very small compared to the state economy. Therefore, small changes in activity may not be accurately reflected by a CGE model.

Input-output (I-O) models are the other standard economic modeling tool used to estimate economic impacts. In contrast to CGE models, I-O models focus exclusively on the links between related sectors of the economy. The goods and services required to construct and operate this industry were estimated through engineering analysis. I-O models are static and thus do not allow for responses to price. However, I-O models are relatively easy to understand and use and are fairly inexpensive. For these reasons, an I-O model was selected to estimate the economic impacts of ethanol production.

Direct impacts for a California ethanol industry include capital and construction, plant operation, feedstock handling,[4] and fuel distribution. Negative impacts include lost economic activity from importing ethanol, changes in electric power production and reductions in gasoline production and handling. It is assumed that labor and other resources are available to support this industry or that they can be made available from outside the state. In an input-output framework, there are three types of economic impacts: direct impacts, indirect impacts, and induced impacts. Direct impacts generally refer to those impacts that occur first in the economy. These first round effects are often associated with changes in employment in an industry or institution. (These impacts can be measured in different metrics: e.g., employment, output, income, value added, etc.) For example, assume that a significant rise in the price of forest products causes paper manufactures to use relatively more recycled paper in their production process. Two direct impacts ensue: employment falls in the forest products industry, while it increases in the paper recycling industry.

Indirect and induced impacts occur after the direct impacts and are often referred to as “secondary impacts.” Indirect impacts reflect changes in downstream support industries. Continuing the example, the forest products industry utilizes fuel for its trucks; employment in the petroleum products industry, therefore, would likely decline due to the reduced demand for forest products. The increased demand for recycled paper, on the other hand, would give rise to

[4] Feedstock handling includes harvesting, processing, collection, storage, and transport.

additional demand for chemicals used in the deinking process. As a result, employment in the chemical manufacturing industry would increase.

Induced impacts are the result of employees spending their disposable income. Changes in expenditure levels generate related employment changes in the manufacture and distribution of consumer products. For example, as shown above, total earnings in both the recycled paper industry and the chemical industry would increase as a result of the increased demand for recycled paper. Part of these increased earnings would be spent on clothing, which would generate employment in its manufacture and distribution.

IV.4 Total Economic Impacts

Indirect and Induced Impacts

In considering the macroeconomic, or economy-wide, implications of a direct impact, two secondary effects must be accounted for: indirect and induced impacts. For the sake of explanation, an ethanol production example will be used to describe these effects.

For the case of a distilling column manufacturer, a direct impact would be the sale of a given distilling column. However, a host of indirect impacts are also triggered by this sale. Any related industries that provide components to the distilling column maker are affected by indirect impacts. For instance, the steel and plastics industries are influenced by the sale of a distilling column.

Induced impacts are similar to indirect impacts, but take place at a broader economic level. To continue the distilling column sales example, each related industry links to the economy in a myriad of ways. Induced impacts account for these economic connections. Spending by employees of column makers and the circulation of this money in the economy are examples of induced effects. Only when direct, indirect, and induced impacts are considered can a given activity be considered a macroeconomic positive or negitive benefit.

Although impacts are often reported in different metrics: e.g., changes in employment, changes in total output, changes in value added, and changes in personal income, in the case of California ethanol production and sales, the macroeconomic metric to be measured is personal income. The main cost of the program will be the government outlays used to promote development of the industry. It is assumed that the opportunity cost on all government funds is taxpayer income. Therefore, all other costs and benefits were defined in a similar manner.

Table IV-1. Summary of Direct Impacts

Capital Expenditures	Zero CA Ethanol	CA Ethanol
Plant Equipment	0	250.0
Plant Construction	0	386.4
Ethanol Storage/Distribution	0	51.5
Biomass Collection Equipment	3.4	26.7

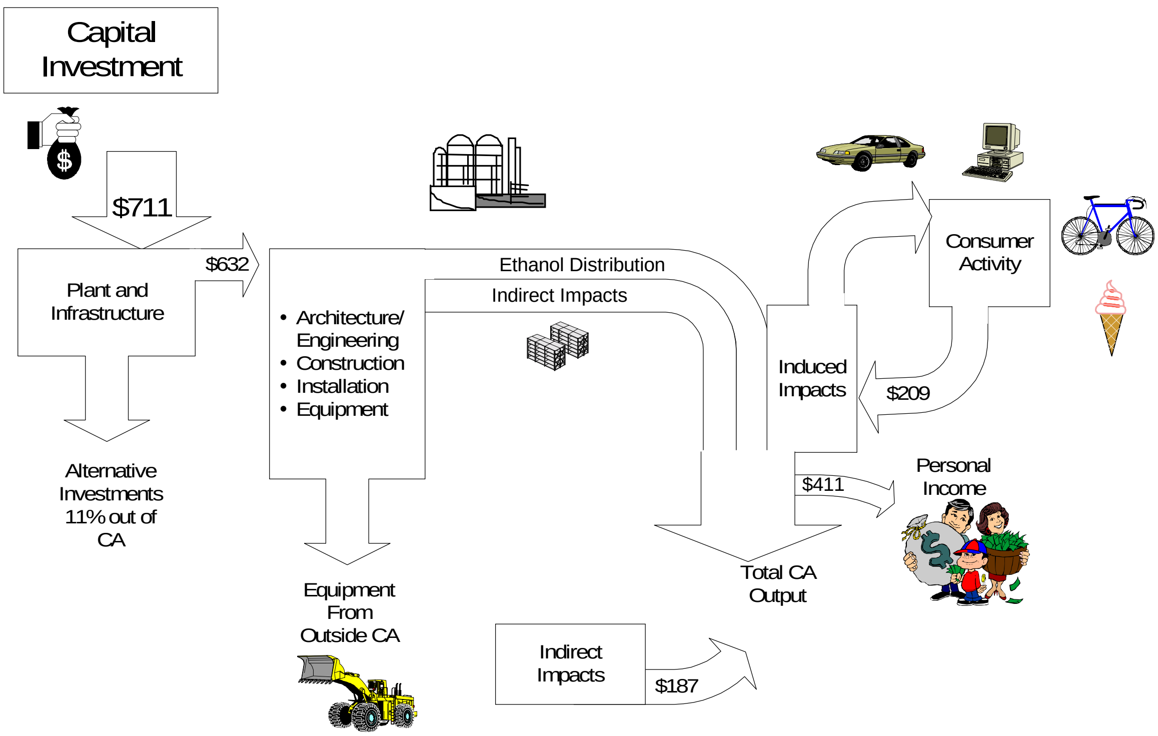


Figure IV-1. Economic Output and Personal Income from Capital Investment

Figure IV-1 shows how ethanol plant construction results in economic output in California. The total capital investment is $711 million for a 200 million gallon per year industry. Alternative uses, the opportunity cost, of these funds determine the impact on the State. If the invested funds were not invested in the California ethanol industry, they would be invested in other opportunities throughout the country. If this were to occur, approximately 11% of the funds would be invested in some other California opportunity, based on recent investment averages. This investment that would occur in California even without the ethanol industry is subtracted from the total capital investment.[5] The 11 percent of investment that would have occurred is not counted as new, to avoid double counting these effects.

The remaining $538 million provides architectural and engineering services, construction, installation, and equipment that would otherwise not have occurred. Of this investment, $112 million was estimated to occur outside the state. The remaining capital investment is analyzed in an input/output model which determines indirect economic impacts (such as economic activity in the steel industry), and induced impacts (consumer activity generated by employee spending) to determine the total economic output for capital investment ($863 million). The I-O model results also predict employment, personal income, and value added. All of the construction activity results in positive economic impacts.

The key economic parameter addressed in this section is personal income. Data on employment levels in the counties that are candidates for ethanol plants was used to determine the growth in personal income. For construction activities personal income is $411 million over a 20-year period.

Figure IV-2 illustrates the economic impacts of plant operation. The values in this figure represent personal income. The primary operating inputs are feedstock handling, plant operation, and fuel distribution which as well as materials such as water, acid, and enzymes. The California ethanol industry would result in a reduction in economic activity from the importation of ethanol from the Midwest. Economic activity from ship and railcar unloading are reduced and this effect is counted as a loss in personal income ($177 million) or an economic cost to the State. Fuel transportation activities to in-land bulk terminals are counted as economic benefits.

California ethanol production would also change the dynamics of power production in the state. The total consumption of power in the state would increase as a result of the electricity used in the ethanol production process. On the supply side, the integration of biomass power plants and ethanol production facilities would lead to shifts in the amount of electricity supplied by different power sources. Compared to the Zero California ethanol case, the amount of power produced by biomass plants would decline. This would occur because of the high cost of additional feedstock that would be needed to supply the collocated facilities. The fall in biomass power production would mean that California and/or out-of-state utilities would have to increase production to meet other consumer demand, which is assumed to remain constant across scenarios. These utilities would also have to increase production to supply the additional demand from the new stand alone ethanol production plants. It is assumed that the increase in production from California utilities would more than offset the decline in biomass power production, resulting in a net positive impact on the California economy.

The economic output related to ethanol plant operation and bulk fuel distribution is an input to the IMPLAN model, which estimates indirect and induced impacts in a similar manner the

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[5]The net capital investment is $499 million. The alternative investment that would have occurred in the State is not viewed as a cost.

capital costs. Personal income related to ethanol plant operation is $1,428 million over a 20 year period.

The use of feedstocks such as forest thinnings and agricultural residue results in environmental benefits, which are not readily achieved through other means and warrant State participation to achieve these environmental benefits. Valuing the environmental benefits in terms of economic benefits is difficult since mitigating the impacts of forest damage and fire prevention cost also result in economic activity for the State. Therefore, valuations of the environmental benefits are treated separately.

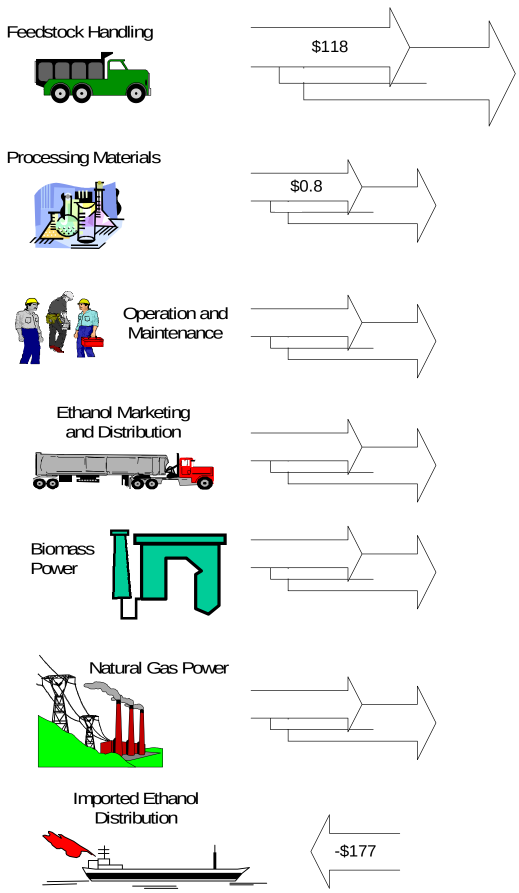


Figure IV-2. Personal Income from Ethanol Production — Direct Impacts

The combined capital and operating cost elements of a California ethanol production industry result in impacts that are primarily economic benefits with few economic costs. However, many of the feedstocks considered for ethanol production may be too costly to achieve an economic cost of ethanol production in the near-term. The State may provide funding for forest thinning, ethanol producer price payments, or funding for plant construction in order to achieve the environmental benefits associated with ethanol production. The options for supporting an ethanol industry are discussed in Chapter IX. State outlays that support an ethanol industry result in the primary economic costs to the State. Alternatively the State could retire debt, reduce taxes, or use funds for other activities that result in economic benefits to the State. The impact of

State outlays was treated as a reduced opportunity for tax reductions or income to taxpayers. This income to taxpayers would also result in indirect and induced impacts.

State outlays equivalent to $0.36 per gallon for 12 years were analyzed. This level of subsidy would be consistent with $30/ton of feedstock and results in an economic cost of $761 million over 20 years.

The justification for State support would be in part the environmental benefits associated with feedstock removal, the economic benefits provide a substantial return to the State. The economic costs and benefits are illustrated in Figure IV-3 as personal income. As discussed previously, the primary economic cost to the State is due to outlays supporting the Ethanol Employment levels within the state are of particular importance in determining if ethanol production is a macroeconomic cost or benefit. While an ethanol production industry will create open positions for workers, that does not mean that jobs will be created at a state level. For instance, if an ethanol plant opened in an area with fullemployment, the plant would create a demand for labor that does not exist. In so doing, opening the plant would simply increase the cost of labor to all employers. This would be a negitive impact on the region, as the price of goods and services offered to the consumer would have to increase to compensate for increased labor costs. This means that the specific location of any ethanol-related activities must be considered in determining the impact on GSP. It is assumed that all production activities occur in regions with less than full employment or that new non-California labor will migrate to the area to meet expanded regional labor needs. As many of the plants will be located in rural areas that traditionally suffer higher unemployment levels than urban areas, this is not considered a highly restrictive assumption.

In addition to labor, another issue that requires careful consideration is the collocation of ethanol plants with biomass power generation. Since lignin, a by-product of biomass-to-ethanol production, can be used as a power plant fuel, a hybrid ethanol/electricity plant can be installed. Consequently, an ethanol industry will produce not only transportation fuel, but also power that can be sold to electric utilities. The question remains: How does one evaluate this by-product? It is simultaneously a source of secondary revenue for ethanol producers, and a “common” good to the California population resulting in additional power capacity.

Figure IV-3 illustrates the total costs and benefits of a California ethanol industry. These costs and benefits are represented as personal income. The following discussion analyzes the effect on annual income and employment

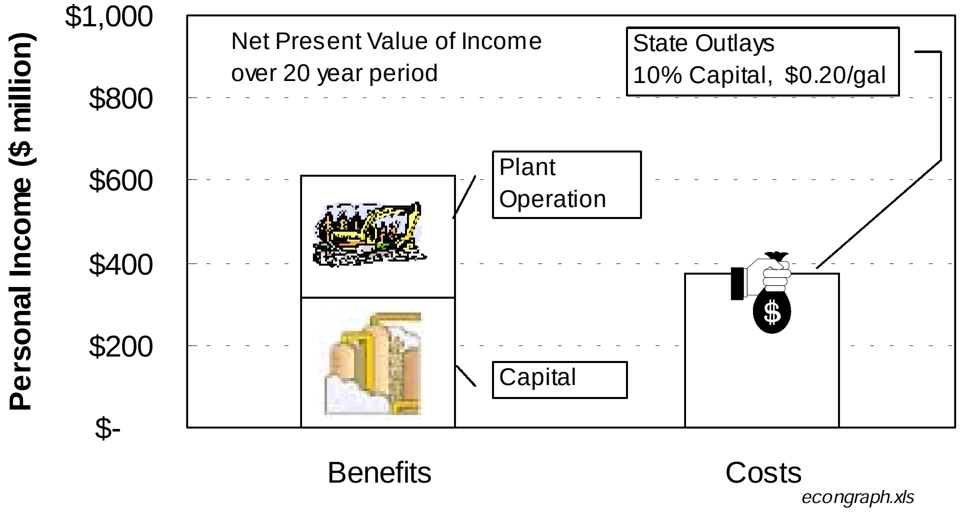


Figure IV-3. Costs and benefits of a California ethanol industry.

Is this biomass power production a separate industry, given that several biomass power plants currently exist in the absence of ethanol production? If so, then careful consideration must be paid to ethanol plants that operate with or without a collocated biomass power facility. The potential impact on California power prices is discussed in Chapter V.

IV.5 What is the Impact of a California Ethanol Industry on Jobs?

New Jobs due to an Ethanol Industry

A host of positions are created by a biomass-to-ethanol industry. These positions stem not only from ethanol plants and biomass collection efforts, but also from the construction of the infrastructure and facilities that make ethanol production possible. Estimated positions directly related to ethanol production include 250 ethanol plant positions and 110 biomass collection jobs per 100 million gallons of annual production.

While these positions are opened by an ethanol industry, the issue of net statewide macroeconomic job creation is a separate issue requiring more analysis than simply counting the job openings in a given sector. For an economy with intertwined industries and labor markets, such as that found in California, creating positions in one sector will cause the economic equilibrium to shift as resources and employees adapt to new market conditions. These macroeconomic employment issues are discussed separately, below.

Changes in Employment

In terms of determining a statewide employment benefit, several factors need to be considered: net wages, reduced welfare, and unemployment insurance. As previously mentioned, the regional and statewide employment levels influence the net benefit or cost of new job openings. In the case of less then full employment, new job openings will result in lower unemployment rates, with minimal wage changes. For regions with full employment, new jobs may push the wage level up or new labor will migrate to the region to meet the demand. Wage changes will increase costs for all employers. This impact must be offset by the benefit realized from ethanol production.

Figure IV-4 illustrates the personal income on an annual basis for a California ethanol industry. The economic benefits result from capital construction and ethanol production activities. These benefits include income from direct, indirect and induced impacts from the I-O model. The negative economic impacts correspond to lost revenue from ethanol import terminal activities and State outlays. For this analysis a producer price payment of $0.20 per gallon for 20 year of plant life was evaluated (note we can do a combination of capital and producer price payments with declining proder payments). Figure IV-5 shows the impact on employment in the State. The impacts correspond to the personal income in Figure IV-4.

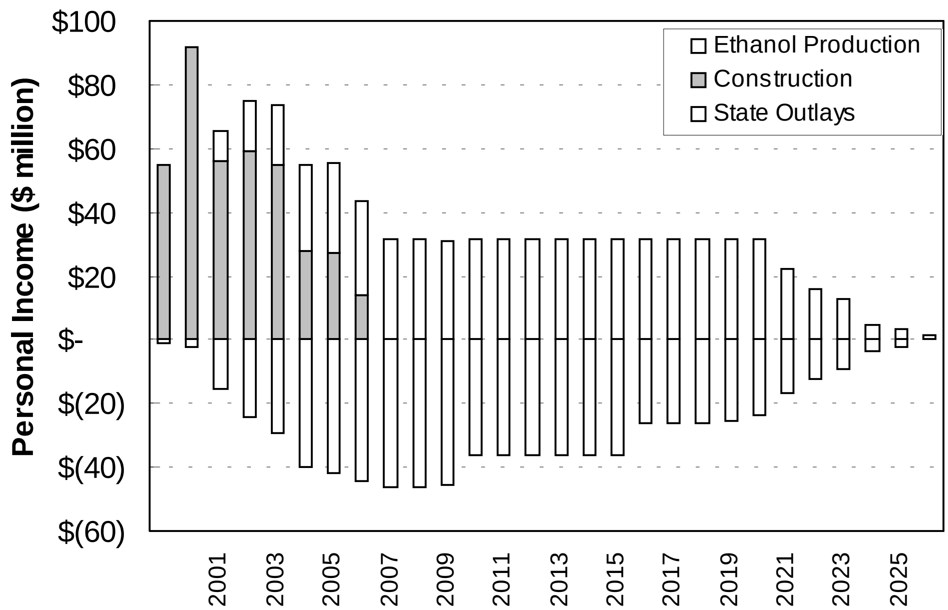


Figure IV-4. Annual changes in personal income in California

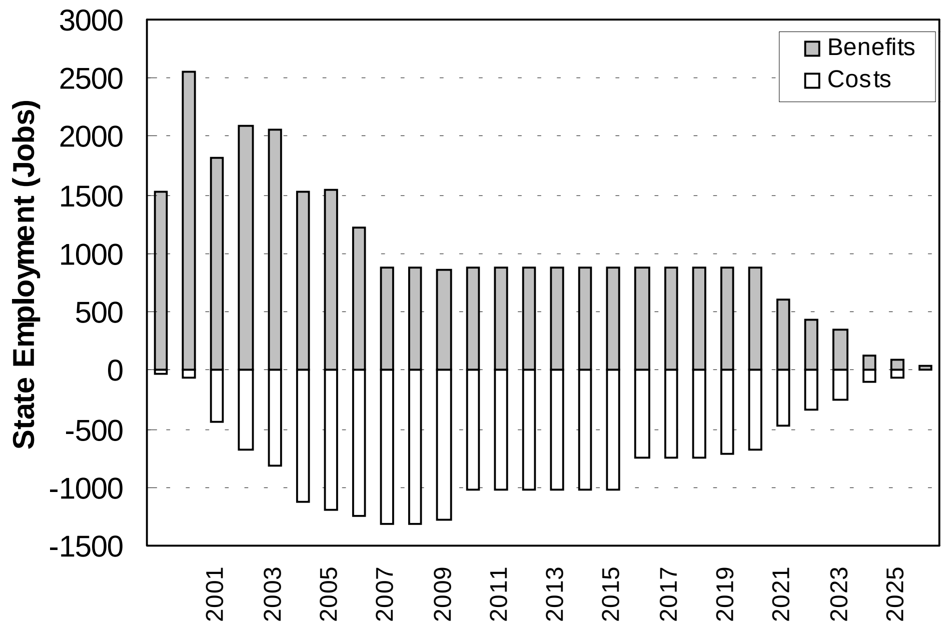


Figure IV-5. Annual changes in employment in California

IV.6 How Can Risk be Minimized for California Ethanol Producers?

The state could implement several measures to promote an California ethanol industry. The key factors that affect the viability of an ethanol industry are:

- High capital costs, especially in the near term as the technology emerges.
- Uncertain feedstock availability and potential high cost for feedstocks with environmental benefits.
- Sales prices that are potentially below the price for viable plant operation.

If the economic and environmental benefits of an ethanol industry warrant it, the state could provide incentives. Several incentive mechanisms are shown in Table IV-2, which include supporting capital purchases, higher ethanol prices, and lower feedstock costs. The merits and shortcomings of these incentives are discussed in this section and analyzed further in Appendix II-A.

Capital Cost Support

State funding has often been used to support capital costs for emerging technologies. The most successful model for capital cost supports combine production requirements with plant co-funding. This approach is being used in Hawaii for sugar cane based ethanol production. Prior experience in Nebraska with loan guarantees resulted in projects that were oriented more towards building a facility than producing ethanol. Minnesota provided reduced interest loans for ethanol plant construction. Ethanol plants in California have been considered for capital cost sharing. Another downside to providing capital support is that the developers' decision to proceed with a project may be delayed as capital support is evaluated. Production based incentives provide a more direct relationship with the ethanol capacity being constructed.

Price Incentives for Ethanol Production

Incentives that support the price of ethanol have historically been used to foster the development of ethanol production infrastructure. The federal tax incentive results in $0.54/gallon. Some states have additional tax incentives and credits. The Nebraska and Minnesota Programs have both been effective. The Minnesota incentives for share ownership increase constituency support for the program by insuring participation in profits after corn has been sold. Minnesota's producer incentive, limited to 10 years per facility, has been effective in expanding the state's ethanol production facilities. Minnesota's program appears to favor smaller production facilities that may be less competitive in a national market. However, a statewide E10 mandate guarantees a broadly dispersed market for splash blending and may ameliorate these problems.

Production incentives are an effective mechanism and are used in many states. They are a proven technique for getting ethanol made and into the market and provide an effective incentive to initiate and expand capital investment. They do not present the same monitoring and enforcement problems that subsidized or guaranteed loans, equity participation, or a "champion" approach may engender. And these at least gave the appearance of a "level playing field." However, if there is a sunset provision in the production incentive (five to ten years being typical), it will have the effect of favoring an initial wave of investment and discouraging subsequent entry. However, the alternative might be to have no industry at all.

Production incentives often take the form of exemption from state excise taxes, on the federal model. However, the Hawaiian model, which provides for a tax credit against income that is refundable if income is insufficient to allow full use of the credit, is an alternative technique that may transfer money to a struggling new industry.

Production incentives are strongest if they are contractually guaranteed so that, once signed, they no longer depend upon legislative actions. Thus, if the legislature abolishes and incentive program, it would not be able to "strand" investors that had already put an ethanol plant into production.

An alternative to price incentives are minimum price guarantees for specific amounts produced, contractually guaranteed over a period of time, that would help startup ethanol plants attract investment capital. The state would take or pay for ethanol produced by firms. This mechanism would reduce the State's exposure to paying incentives. However, monitoring requirements are complex. Adjusting the incentive to the price of gasoline, which is a much more widely sold product, may be effective. The current Federal Tax incentive is lowered as gasoline prices increase.

Adjusting an incentive to the price of gasoline would also serve to make the State's overall expenses more constant. As gasoline prices dropped, the state would save money from its own fuel purchases while spending more on ethanol incentives.

Price incentives have proven to be effective in the past toward supporting an ethanol industry. If the benefits of an ethanol industry proved worthy of State support, the challenge would be to minimize State expenditures while still assuring stable market development.

Feedstock Incentives

Incentives to an ethanol industry may have unintended consequences regarding the use of feedstocks. Some feedstocks that provide the most significant environmental benefits such as forest thinnings and rice straw may not prove to be the feedstocks of choice for an ethanol industry. In the event of high ethanol prices, producers may even compete for waste paper or wood chips that are currently utilized in other industries. Supporting feedstocks with environmental benefits would have the most direct impact on utilizing these feedstocks.

If a feedstock credit were made available for forest thinning or rice straw removal, these feedstocks would be available for alternative uses and might not be converted to ethanol. Ethanol production is favored by the $0.54/gal federal tax incentive. In the absence of this credit, power production may be a more economic alternative.

The $0.54/gallon tax incentive for ethanol translates into about $40/ton of forest material. A similar level of support for the power production industry — arguably a more cost effective means of using forest thinnings — would ensure its viability. However, the current incentive structure is geared towards producing ethanol.

Table IV-2 summarizes these methods to reduce risk to California ethanol producers.

One way an ethanol production industry could impact the State's economy is through its potential effects on fuel and energy costs. The relationship between ethanol and fuel and electricity prices is described in the following chapter, which discusses how an ethanol industry could influence energy production and use.

References

(1) Russ Kinzig – Kinder Morgan at the DOE Ethanol Workshop (Sacramento), October 5, 1999.

(2) RFG/MTBE Issues and Options in the Northeast – Downstream Alternatives, Inc., May , 1999

Table IV-2. Options for Supporting a California Ethanol Industry

Approach	5-Year Cost to State[a]	Pro's and Con's
Capital cofunding 50% cost share	$200 to $400 million	Traditional mechanism for CA funding. Incentivizes higher cost and more small facilities. Does not guarantee production. Delays project until funding is committed.
Loan Guarantees	100 to 600 million	Lower cast than capital subsidy. Default risk. Does not guarantee production.
Capital cofunding $0.5/annual gallon	$100 million	Incentivizes fewer large facilities. Promotes higher ethanol yields.
Producer Incentive $0.40/gal	$400 million	Large incentive would assure production. Unintended feedstocks could be used[b].
Feedstock subsidy $30/ton	$350 to $450 million	Targets feedstocks with environmental consequences. May divert feedstocks to alternative use[c].
Ethanol Price support $1.40 minimum	$0 to $450 million	Potential low cost to the state. High subsidies for cheap ethanol would be offset by low gasoline prices. Potential for market manipulation. Higher price levels may be needed to start an industry.

[a] For 200 million gallons per year production.
[b] For example, recycled waste paper or imported corn could be feedstocks.
[c] Alternative uses such as biomass power, gardening materials, livestock bedding, paper production.

CHAPTER V

EFFECTS OF CALIFORNIA ETHANOL ON ENERGY USE

V. Effects of California Ethanol on Energy Use

This section discusses the energy impacts of California ethanol production. These impacts include benefits from an indigenous source of fuel as well as impacts on electricity generation, fossil fuel use and petroleum use. Biomass based ethanol would provide another supply of fuel for California where fuel shortages have historically been a concern. Furthermore, with the planned phase out of MTBE in California and potential reductions of MTBE use in the U.S., ethanol shortages could occur. California ethanol production capacity would compete with imported ethanol so an ethanol industry in California would result in downward pressure on ethanol and to some extent gasoline prices. In addition to producing a source of fuel, ethanol plants would consume power and collocated plants would generate more than they consume. The potential impact of ethanol production on power generation is also analyzed. The costs and benefits of producing ethanol in the State were analyzed in the prior section, which takes into account the effect of the revenue generated from ethanol sales on the economy. The potential impacts on consumer fuel prices and other energy impacts are considered in this section.

V.1 Electric Power Production

Status of Biomass Power Plants

California's installed capacity for electricity generation from biomass plants neared 750 MWe from 66 direct combustion facilities during its peak in 1990. At present there are about 29 operational plants and 16 idle plants with a total online capacity of nominally 600 MWe. Table V-1 presents a list of the operational biomass plants, plant electricity generation capacity, and biomass source.

The suitability of collocation of a biomass-ethanol manufacturing facility with a biomass power plant depends on a number of factors. Three key factors are elaborated below:

- Compatible feedstock. Power plants using mill wastes, forest residues/thinnings, agricultural residues, and urban wood wastes make good candidates for ethanol production.

- Feedstock availability. Collocation may result in competition for the same feedstock. Under the current climate of high-energy demand in the state, the use of biomass for power generation is economically attractive again. Collocation strategy should include the capacity to cover simultaneous peak demands of power and ethanol for long periods of time.

- Proximity to major highways or railroad facilities is important for the continuous bulk movement of ethanol from the production facility.

The construction and operation of the ethanol plant would be subject to a number of local and state level regulations. Operation of the biomass powerplant is also regulated by a number of local, state and federal air, water and disposal permits. Lignin, a by-product of ethanol production is a potential combustion fuel. The use of lignin as a fuel by the power plant may require a simple modification to the existing permits. Plants that have been shut down and

Table V-1. Operational Biomass Power Plants – 2000

Project	County	Net MW	mBDT/y	Status	Startup	Shutdown
Western Power	Imperial	15.0	122	Idle	1990	1996
Colmac Energy	Riverside	47.0	330	Operating	1992	
Apex Orchard	Kem	5.5	48	Idle	1983	1988
Thermo Ecotak Dalano	Tulare	48.0	375	Operating	1991	
Sierra Forest Products	Tulare	9.3	75	Idle	1986	1994
Dinuba Energy	Tulare	11.5	97	Idle	1988	1995
Auberry	Fresno	7.5	70	Idle	1986	1994
Soledad Energy	Monterey	13.5	98	Idle	1990	1994
Thermo Ecotek Mandota	Fresno	25.0	185	Operating	1990	
Rio Bravo Fresno	Fresno	25.0	180	Operating	1989	1994
SJVEP-Madera	Madera	25.0	182	Idle	1990	1995
SJVEP-El Nido	Merced	10.2	88	Idle	1989	1995
SJVEP-Chowchilla II	Madera	10.8	90	Idle	1990	1995
Redwood Food Pkg	Stanislaus	4.5	36	Idle	1980	1985
Tracy Biomass	San Joaquin	19.5	150	Operating	1990	
Diamond Walnut	San Joaquin	4.5	35	Operating	1981	
California Cedar Products	San Joaquin	0.8	11	Idle	1984	1991
Jackson Valley, Ione	Amador	18.0	140	Idle	1988	
Fiberboard, Standard	Tuolumne	3.0	27	Idle	1983	1996
Chinese Station	Tuolumne	22.0	174	Operating	1987	
Thermo Ecotak Woodland	Yolo	25.0	200	Operating	1990	
Wheelabrator Martell	Amador	18.0	135	Operating	1987	
Rio Bravo Rocklin	Placer	25.0	180	Operating	1990	1994
Sierra Pacific Lincoln	Placer	8.0	70	Operating	1985	
Wadham Energy	Colusa	26.5	209	Operating	1989	
Georgia Pacific	Mendacino	15.0	119	Operating	1987	
Koppers	Butte	5.5	110	Idle	1984	1984
Ogden Pacific Oroville	Butte	18.0	142	Operating	1986	
Sierra Pac. Loyalton	Sierra	17.0	134	Operating	1990	
Sierra Pacific Quincy	Plumas	25.0	200	Operating	1987	
Collins Pine	Plumas	12.0	90	Operating	1988	
Sierra Pac. Susanville	Lassen	13.0	105	Operating	1985	
Ogden Westwood	Lassen	11.4	90	Operating	1985	
Honey Lake Power	Lassen	30.0	225	Operating	1989	
Big Valley Lumber	Lassen	7.5	59	Operating	1983	
Sierra Pacific Burney	Shasta	17.0	145	Operating	1987	
Odgen Burney	Shasta	10.0	77	Operating	1985	
Burney Forest Products	Shasta	31.0	245	Operating	1990	
Wheelabrator Shasta	Shasta	50.0	380	Operating	1988	
Wheelabrator Hudson	Shasta	6.0	66	Operating	1981	
Sierra Pacific Anderson	Shasta	4.0	60	Operating	1998	
LP Samoa	Humboldt	27.5	300	Idle	1985	1991
Blue Lake	Humboldt	10.0	79	Idle	1985	1999
Pacific Lumber	Humboldt	23.0	225	Operating	1988	
Fairhaven Power	Humboldt	17.3	140	Operating	1987	

are candidates for re-startup will require a new permit if the original permit has either expired or was surrendered.

Biomass power plants are subject to the vagaries of the demand for electricity. It used to be that forest wood based power plants operated mainly in the spring and summer months when the demand for electricity increased and there was less moisture in the fuel. However, the increasing demand for electricity may make year around availability economically feasible. The need for continuous availability of the power plant along with the collocated ethanol plant feedstock demands may trigger a shortage of feedstock and/or result in economically viable expanded harvesting of forest residues.

The Amount of Electric Power Produced

The various ethanol production options considered in this study result in different amounts of electric power that are produced or consumed. The types of ethanol plants are categorized in Table V-2. Biomass power plants would produce the most electric power for a fixed amount of feedstock; however, the economic viability of biomass power production alone has proven to be tenuous in the past.

Table V-2. Electric power output from biomass facilities

Plant Type	Feedstock	Electric Power Impact[a]
Existing Power Plant	Forest material Woody biomass	25-49 MW, 112-390 GWh/yr
Collocated Ethanol Plant	Forest material Woody biomass	15-49 MW (peak), 40-80 GWh/yr
Collocated Ethanol Plant	Agricultural residue with Rice straw	15-49 MW (peak), 35-80 GWh/yr
Stand-alone Urban Ethanol Plant	Waste paper, urban waste	-1.5 MW, -12 GWh/yr

[a] Power output varies with ethanol production capacity. Stand alone facility consumes electric power and natural gas.

Forest material can also be used to generate ethanol and electric power. Even though forest thinnings have a relatively high moisture content, this material is also used as fuel in biomass power plants.

Five collocated power plants comprised the assumptions for this study (in addition to four stand-alone facilities). When operating as biomass power plants these facilities would have a peak generation capacity of 175 MW. This generation capacity represents 0.6 percent of the State’s total generation capacity of 30,000 MW. However, even relatively small amounts of generation capacity are important when power is in short supply.[6] Table V-3 shows the key assumptions related to energy prices and use for this study. Higher ethanol prices favor a California ethanol industry while higher power prices represent an opportunity cost to the ethanol industry.

Table V-3. Energy-related assumptions

Scenario	*Zero CA Ethanol* Operating Biomass Power plants	*CA Ethanol* Collocated Ethanol Plants	Ethanol Price ($/gal)	Net Power Impact		Electric Power ($/kWh)	Natural Gas ($/MMBtu)
				Capacity (MW)	Generation (GWh/yr)		
1	5	5	$ 1.70	-6	-948	0.08	3.0
2	1	5	$ 1.44	135	92	0.08	3.0
3	5	5	$ 2.00	-6	-948	0.24	4.0
4	5	5	$ 1.10	105	-428	0.04	3.0
5	5	5	$ 1.44	105	-428	0.04	3.0

Note: Scenario 1 is the basis for the analyses in this report. Scenarios 2-5 are potential alternatives for energy use.

Figures V-1a and V-1b illustrate the effect of an ethanol industry on power generation capacity. These represent the range in assumptions for the fate of the biomass power industry with zero California ethanol production. Biomass power plants would either be sustainable over the long term or competition from new natural gas fired generation would prevent them from being economically viable. As illustrated in these figures, peak generation capacity would not be substantially affected if power plants were collocated with ethanol plants as they could continue to generate at peak capacity during periods of peak demand, as long as sufficient feedstock is available. Very few locations have sufficient biomass resources, at acceptable cost, to provide fuel for both power production and ethanol production at peak capacity. Figure V-1b illustrates the range of impacts on annual power generation. In Scenario 1, biomass generation capacity is reduced and lignin from ethanol production is used to generate power. Scenario 2 assumes that the biomass power industry would not be economically viable without ethanol production. Under these circumstances, annual power generation would not be reduced but increased instead. The California ethanol production scenario is based upon the former case, Scenario 1.

[6] The difference between a Stage 1 and State 2 power alert is 3 percent or 900MW.

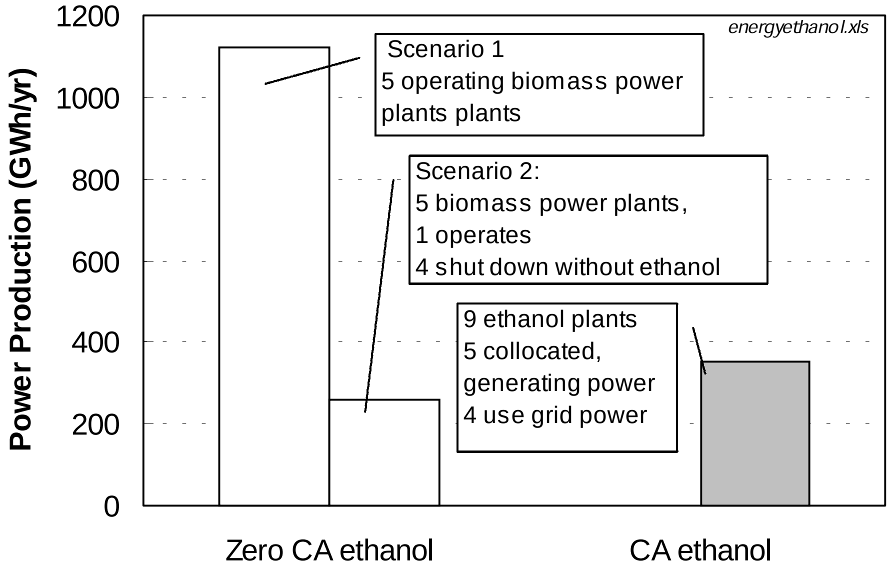


Figure V-1a. Change in Power generation output with ethanol production.

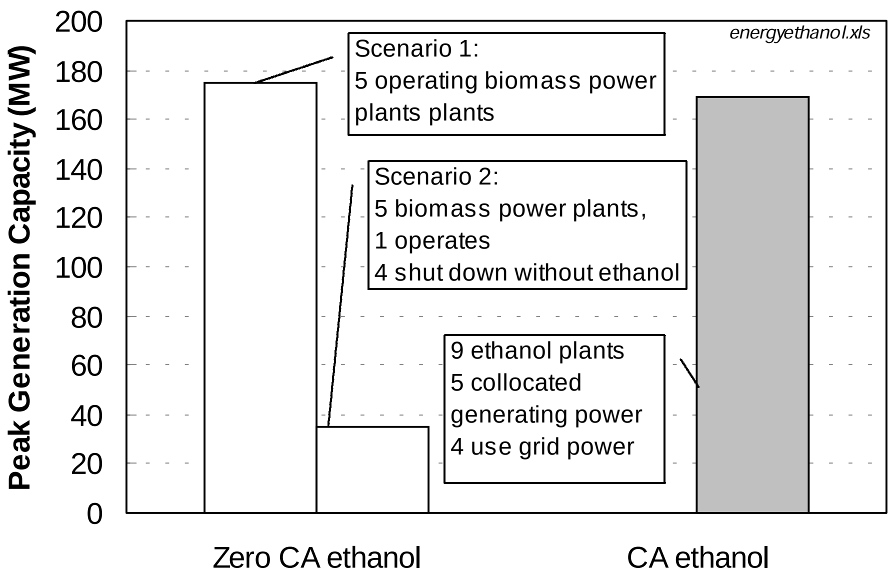


Figure V-1b. Power generation with and without CA ethanol production.

Electric Power Prices

With the mix of facilities and feedstocks assumed in this study, an ethanol industry would provide a modest amount of power to the State. Ethanol plants and biomass power plants compete for some of the same feedstocks. However ethanol plants are potentially more economically viable in the long term and therefore more likely to be built than new biomass power plants. Most of the biomass power plants were built in the 1980s when trends in power prices suggested that it would be favorable to obtain generation capacity from biomass at $0.10/kWh. Biomass power plants entered into contracts with utilities that guaranteed them $0.10/kWh for the first 10 years of operation, after which the price for power would be equivalent to the avoided cost from a utility's natural gas fired power plant. When natural gas prices dropped in the 1990s the viability of biomass power generation came into question as these plants would need to compete with other plants that burn natural gas costing less than $2.00 per million Btu. Even in the year 2001, when biomass power plants are profitable with power prices over $0.20/kWh, the long term viability of such facilities is unclear as it hinges on the price of electric power.

A key variable in the viability of ethanol plants is the Federal tax incentive which is available for ethanol production but not biomass power production. This incentive corresponds to about $40/ton of biomass feedstock.[7]

Additional generation capacity as well would provide power that would compete with existing producers to reduce the price of power. Elevated electricity prices might mean that biomass is worth more for power production than for ethanol production. A collocated power plant would have the flexibility of producing either ethanol or additional power during periods of high power prices. The impacts of biomass power plants on power production and natural gas imports depends upon case by case details for each ethanol production facility. Ethanol production that is added to an operating biomass power plant would reduce the amount of power that is produced for a fixed amount of feedstock, however, feedstock consumption can increase, especially if ethanol production receives support from the State. Facilities that are collocated with power plants that are not commercially viable on their own would result in an increase in power production over the long term. With high power prices, biomass facilities may choose to produce power and only produce ethanol in periods of low power demand.

Conversely, if gasoline prices were to increase, an ethanol industry may want to increase capacity. Increasing ethanol production capacity would come at the expense of biomass power production for a fixed amount of feedstock supply; however as indicated previously, peak power generation would likely not be reduced substantially. Biomass energy facilities have a regional

[7] The federal tax incentive for ethanol amounts to $0.54/gallon. For an ethanol production yield of 78 gallons per ton, the tax exemption translates into $40/ton of feedstock. An additional $0.10 tax incentive is available for small ethanol producers.

influence over their feedstock prices. The high cost of transportation has a tendency to prevent biomass from being shipped too far.

An ethanol business case might have longer term market potential which could attract investors. However, very large urban facilities are unlikely to be produced in the next 5 years. Collocated facilities may have the flexibility to use steam for ethanol production in off peak hours and increase power generation during peak hours.

Electric power shortages occur primarily during peak power demand periods. A collocated biomass power and ethanol plant could be operated in such a manner that its power production capacity at peak times is not reduced compared to a typical biomass power plant.

Natural Gas Imports

As discussed in Chapter III, ethanol production facilities with additional power generation capacity would compete with other power producers in the State.[8] If biomass power production is reduced, power from other sources, which are likely to burn natural gas, on the margin, could be increased. The effect of additional generation capacity could be an increase in natural gas imports to the State.

Ethanol facilities that are located in urban areas would need to either import electric power or produce their own power through cogeneration with natural gas. Ethanol production has often been considered an ideal match for cogeneration. Operating a natural gas boiler or cogeneration facility would require more environmental review and permitting than an existing biomass power plant.

Ethanol plants located in urban areas that require natural gas as a source of heat energy will result in increased electric power demand and natural gas imports. If these plants are located with cogeneration applications, they could enable the construction of additional power generation capacity.

V.2 Fossil Energy Use and Benefits

The energy inputs for fuel production processes are shown in Figure V-2. This figure illustrates the petroleum, natural gas, and coal energy inputs per unit of fuel product for the entire fuel production cycle. For example, the energy inputs for producing diesel fuel include crude oil extraction, transport, and refining. These fuel cycle energy impacts are analyzed in several studies (Wang, MIT), with the values in this study taken from work performed for the Energy Commission (Unnasch 2000). While the results of these studies vary on a gram per mile basis, the greenhouse gases that corespond to the combustion of a gallon of gasoline or ethanol from

[8] During periods of power shortages, additional generation capacity may not displace imports but would simple enable more consumption.

corn are consistent. For example, in the case of gasoline, about 140,000 Btu of total energy are required per gallon of gasoline which contains 113,000 Btu. Therefore the ratio of energy input to fuel output is 1.27 or 127 percent. In the case of ethanol production, the fossil energy input is less than that of the product fuel. When electricity is a byproduct, more energy as electric power is produced than that contained in the ethanol and the net fossil energy input is negative.

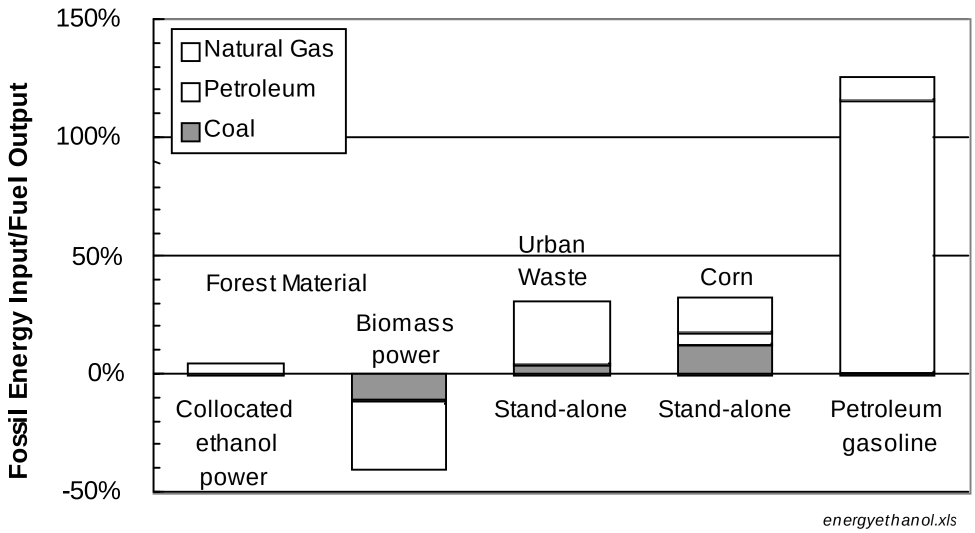


Figure V-2. Fossil fuel energy inputs for ethanol and gasoline production

Energy inputs are shown for ethanol produced from forest material, agricultural residue, rice straw, and urban waste. In addition, the fossil fuel energy inputs for gasoline production are also shown. These results are shown as a fraction of the total energy in ethanol or gasoline. Since ethanol would be used as a component in gasoline, these results are comparable. Ethanol production from the feedstocks considered in this study requires relatively little fossil fuel energy input.

The energy contained in biomass is not shown in these comparisons for several reasons. The biomass energy is not a fossil fuel, and policy makers are more focused on the utilization and conservation of fossil fuels. Furthermore, the biomass energy considered here is a residue that would otherwise not be utilized except possibly for power production.

V.3 Petroleum Use

For the California-ethanol scenario, California produced ethanol displaces ethanol that is imported from the Midwest. The global energy impact of California ethanol production therefore depends upon the energy inputs for the fuel displaced by ethanol. The increases in ethanol production and affected fuel markets are illustrated in Figure V-3. Ethanol produced in California would either displace imported ethanol or California gasoline. If the demand for ethanol is related to oxygenate and octane requirements in gasoline, production in California would displace imports.

The effect of ethanol production depends on whether ethanol supplies are constrained or over abundant. It appears likely that ethanol will be in short supply in the near term and it will also be required as an oxygenate. Under these circumstances, ethanol produced in California would displace imported ethanol. As ethanol might also be in short supply outside of California, Midwest ethanol would be sold elsewhere. Thus 200 million gallons of California-ethanol would result in 200 million gallons of Midwest-ethanol being sold elsewhere. This sale would displace the sale of 148 million gallons of gasoline. In the event of an abundant ethanol supply, any ethanol that is produced in California would result in the reduction in the Midwest ethanol capacity. In the long term, factors such as gasoline prices, ethanol production costs, refinery oxygenate and octane requirements, as well as transportation costs will determine the market share of these fuels.

The energy inputs for corn-based ethanol production and gasoline production are evaluated. The energy impacts of ethanol production depend upon a variety of factors that are illustrated for each of the feedstock categories discussed below. In general, for all of the ethanol production options from waste feedstocks the energy contained in the ethanol product is far greater than the fossil fuel energy inputs.

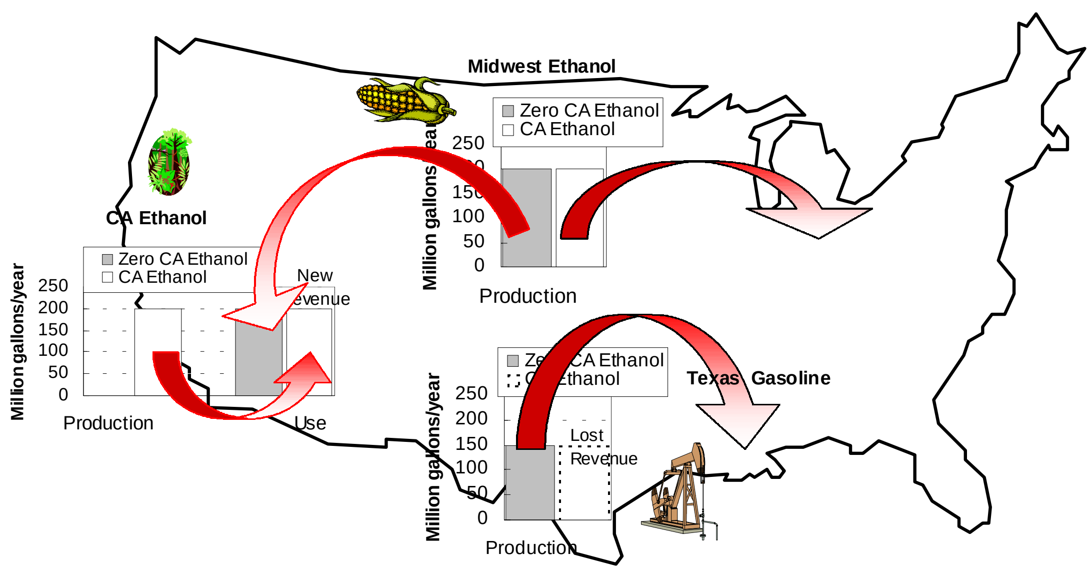


Figure V-3. Changes in energy production with California ethanol

Energy Inputs for Ethanol Production from Corn

Imported ethanol is produced from corn with energy inputs illustrated in Table V-4. Producing ethanol from corn requires energy for the production of fertilizers, corn drying, and processing into ethanol. These energy inputs are provided by natural gas and coal. Corn to ethanol plants produce by-products including corn oil and animal feed products. When evaluating the energy inputs for ethanol production, a fraction of the energy inputs (about 39 percent) for producing corn and processing ethanol are typically allocated to the byproducts. In addition to the energy required for ethanol production, the fuel must be transported to California either by rail car or tanker ship.

Table V-4. Energy Inputs for Ethanol Production from Corn

Process	Primary Energy	Energy Input (Btu/gal)
Fertilizer	Natural Gas	4300
Farm equipment	Diesel	2100
Ethanol plant	Coal/Natural Gas	34,000
Fuel Transport	Diesel	1300
Total Fossil Energy	—	41,700
Allocation to Coproducts	—	15,000
Transport to California	Diesel	2900
Net Fossil Energy	—	23,000

Energy Inputs for Ethanol Production from Biomass

Producing ethanol from biomass in California involves various energy inputs depending upon the feedstock and production technology. Biomass based ethanol production falls into several categories depending upon the type of fossil fuel energy inputs. Forest material and agricultural residue generally provide residual lignin or cellulose residue to generate sufficient steam for ethanol production. Rice straw and urban paper or other materials are unlikely to be burned, and ethanol production facilities would require natural gas for processing energy.

Forest Material and Woody Biomass Residue

For forest material and other woody biomass residues, the primary fossil fuel input is diesel fuel for collecting and hauling the feedstock. Residual lignin and cellulose are burned to produce steam for the ethanol production process. Additional energy from the combustion of lignin is used to produce electric power. The energy inputs for the collection of agricultural residue are similar to those for forest material.

Ethanol produced from forest material requires relatively little fossil fuel input. Since forest residue would be collected for fire control, the only energy input is diesel fuel required for collection and transport to ethanol production facilities. Excess cellulose and lignin provide the energy for ethanol production, so almost no fossil fuels are used in this type of ethanol plant.

Rice Straw

Some feedstocks result in residues that cannot readily be burned in an ethanol production facility, so process heat and electric power must be provided for the ethanol plant. Rice straw contains high levels of silica that prevent it or its residue from being burned in a boiler. Experience with biomass power plants has indicated that silica particles in the combustion products are too abrasive to boiler tubes to allow rice straw or high silica containing materials to be burned. Ethanol from rice straw requires somewhat more diesel fuel energy input than ethanol from woody biomass. Also, more tons of rice straw are required per ton of ethanol, requiring more truck transportation. In addition, residual material containing lignin and silica must be hauled away as an agricultural amendment.

While rice straw residue cannot be used to generate power or steam for ethanol production, an agriculture based ethanol plant can still burn other biomass to generate electric power when rice straw is being converted to ethanol. This biomass energy input would avoid the supplemental use of natural gas. Ethanol plants could operate exclusively on rice straw when this feedstock is available. Residual lignin from rice straw would contain high levels of silica and it would be advantageous to minimize the production of this material which cannot be burned in boilers.

Urban Waste

In urban areas, waste paper, alternative daily cover, and other urban wastes would be the feedstock for an ethanol plant (see Chaper III.5). It is unlikely that a new facility in an urban area would be permitted for burning solid fuels. In addition, waste paper residue would contain some plastic that would be unacceptable to burn in ethanol plants located in urban areas. Consequently, ethanol produced from urban waste would require natural gas to produce process steam and would use electric power from the grid. Cogeneration of electric power could also be an option if the waste heat from the cogeneration matched the requirements for ethanol production. Diesel fuel inputs for urban waste facilities would be minimal, as waste materials would already be hauled to MRFs or transfer stations. Since ethanol production would reduce the amount of material that is added to a landfill, diesel fuel consumption would also be reduced.

V.4 Effect on Consumer Fuel Prices

How Would a California Ethanol Industry Affect Consumer Fuel Costs?

Gasoline prices in California are driven by crude oil prices, refinery capacity, and constraints on meeting California fuel specifications. Ethanol, when used as a blending component for gasoline, increases refinery product volume, increases octane and provides a source of oxygen if required by fuel specifications.

California-ethanol could benefit consumers by providing an additional source of fuel. This ethanol would compete with ethanol that is imported from the Midwest, so California ethanol prices would be the same as other ethanol prices. However, in the event of a shortage of gasoline or ethanol an additional imported supply would help temper any price spikes. As the quantity of

California ethanol may represent a significant fraction of the State's total consumption in the long-term, it could contribute a reduction in gasoline prices.

To the extent that ethanol is required to meet oxygenate or octane requirements, a shortage of ethanol can have a significant impact on the price of gasoline. This effect during a methanol shortage in 1996, resulted in a sharp price spike when MTBE and methanol prices rose sharply. California would be subject to similar price effects when ethanol is used in gasoline.

How Would Imported Ethanol Impact Consumer Fuel Costs?

Imports from the Midwest will be the principal source of ethanol in the near term. The price of ethanol, if required for gasoline blending, would track the price of gasoline unless there is a shortage of ethanol. In the event of an ethanol shortage, the price of ethanol would be determined by price rationing from suppliers. Much higher ethanol prices can be anticipated which would affect gasoline prices also. As ethanol would be blended into gasoline at 5.7 percent, a $0.50 increase in the price of ethanol would result in a $0.03 increase in the cost of gasoline. The consumer fuel prices would be at least $0.03/gal higher; however, actual gasoline prices might rise more. Methanol price increases up to $1.50/gallon in 1996 coincided with retail gasoline price increases of over $0.30/gallon even though oil prices remained relatively low. While the relationship between gasoline prices and methanol prices is not clear, it appears that finished gasoline and ethanol could both be in short supply as MTBE is phased out.

California production capacity could help mitigate the effect of an ethanol shortage on gasoline prices. The effect of ethanol prices on gasoline will be determined well before significant ethanol production capacity can be built in California. With the phase out of MTBE by the end of 2002, ethanol will be blended into gasoline before production capacity could come on line in California.

If Ethanol Were Required in Gasoline, What Would Happen in the Interim Period Before Plants are Built in California?

California ethanol capacity will take several years to come on line even if California commits significant resources to an ethanol industry. An aggressive projection would be 200 million gallons by 2007. In the interim period, the ethanol price would be higher if it were required as a gasoline blending component throughout the U.S. If MTBE were removed from gasoline throughout the U.S., the price of ethanol could reach over $2/gallon with wholesale gasoline prices of $0.82/gal as illustrated in Figure V-4. Additional ethanol production capacity would moderate such price increases.

The principle for estimating the price of ethanol imported to California lies in the value of ethanol as a blending component in other states that use ethanol/gasoline blends. The cost of "bidding away" ethanol from gasoline use in other states and transporting the fuel to California was the basis for the values in Figure V-4. Some states have tax credits for ethanol production and purchasing ethanol from these states where it would receive a tax credit above the $0.54/gallon federal tax exemption increases its cost. The extent of tax credits and ethanol production capacity is factored into this analysis.

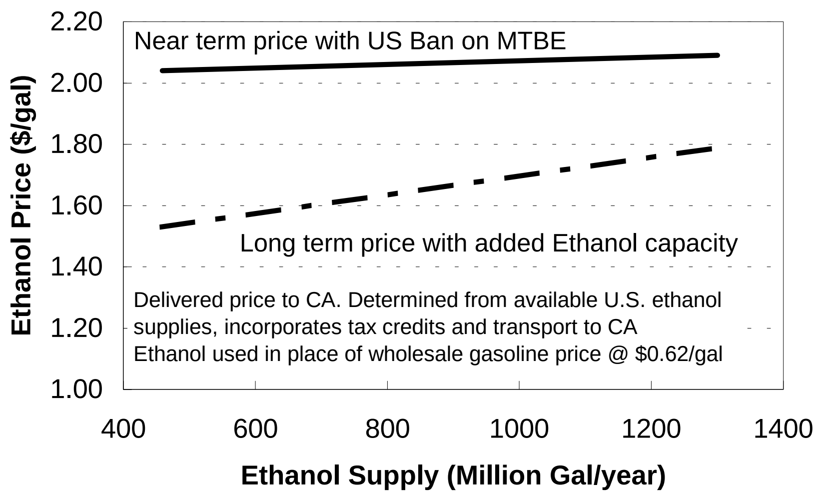


Figure V-4. Near-term ethanol prices are expected to rise to over $2/gallon in the event of a U.S. ban on MTBE.

As discussed in Chapter III, the demand generated by oxygenate requirements in California could be well over 600 million gallons per year. Additional California capacity could help reduce demand induced price increases.

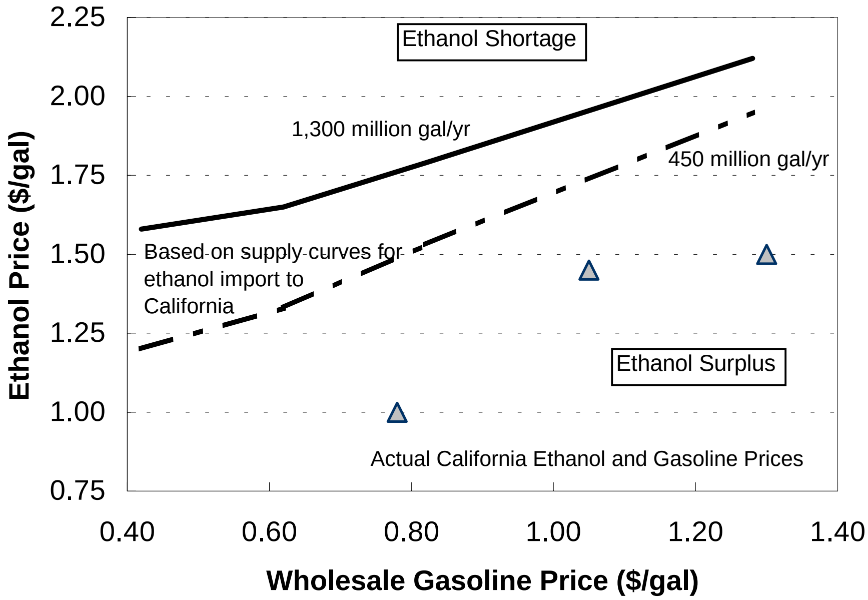
How Does the Price of Gasoline Affect the Ethanol Industry?

Ethanol prices are influenced by several key factors, tax incentives, demand for ethanol to meet refinery octane and oxygenate requirements, as well as gasoline prices. As MTBE is removed from gasoline, ethanol is expected to be a blending component. Several California refineries are proceeding with modifications to blend ethanol with gasoline (CEC).

Once refineries are using ethanol, the price of ethanol is generally related to the price of gasoline. Depending upon market conditions, there may be a premium for oxygenate and octane requirements or a discount if refineries do not need ethanol to meet their blending requirements. This price relationship was analyzed by ESAI for the California Energy Commission (CEC 1999e).

The relationship between fuel ethanol prices and wholesale gasoline supply is shown in Figure V-5. The price of ethanol shipped to California depends upon its alternative use as a gasoline blending component in the Midwest. As gasoline prices rise, the price that must be paid for ethanol also rises if refineries are able to use ethanol. The “bid away” prices correspond to the price that would be needed to purchase ethanol from the Midwest and ship the fuel to California. The high and low range correspond to the extent of California demand and reflect long term production capacity. High demand with near term capacity would result in higher prices shown in Figure V-4. In instances where refineries are not blending with ethanol, a surplus of ethanol would exist and prices would be lower than those indicated in the Figure V-5. Also shown in the figure are actual ethanol prices plotted against the price of gasoline. The actual prices are much lower since the amount of ethanol that is currently used in gasoline is very low.

In the near-term, the price of ethanol is expected to be much higher if MTBE is banned in the U.S. and ethanol is used as an oxygenate. Under these circumstances, mandated requirements for ethanol would result in a demand that exceeds supply, placing an upward pressure on prices.



Source: ESAI

Figure V-5. Projected long-term Ethanol and Gasoline price correlation.

The viability of ethanol plants is driven by the sales price of ethanol. Depending upon the cost of feedstock, plant size, production technology and other cost factors (CEC 1999a), ethanol plants can operate economically with ethanol prices ranging from $1.30 to $1.70 in the near term and possibly below $1/gallon for longer term plants that operate more efficiently.

The price of gasoline tracks the price of oil and is also affected by refinery capacity and gasoline demand. This importance of refinery capacity and gasoline distribution is reflected in the history of gasoline prices. Gasoline prices went up with refinery fires in California and pipeline disruptions in the Midwest.

The recent history of gasoline prices is shown in Figure V-6. As indicated, the wholesale price of gasoline has ranged from $0.65 to $1.20/gal with recent prices being above $0.80/gal. At this gasoline price, the price required to import ethanol from the Midwest would be over $1.65/gal with an ethanol demand of 450 million gallons per year in the State. The price of imported ethanol would reflect the price that could be achieved for California ethanol. If wholesale gasoline prices were to drop, the potential selling price of ethanol would also be reduced.

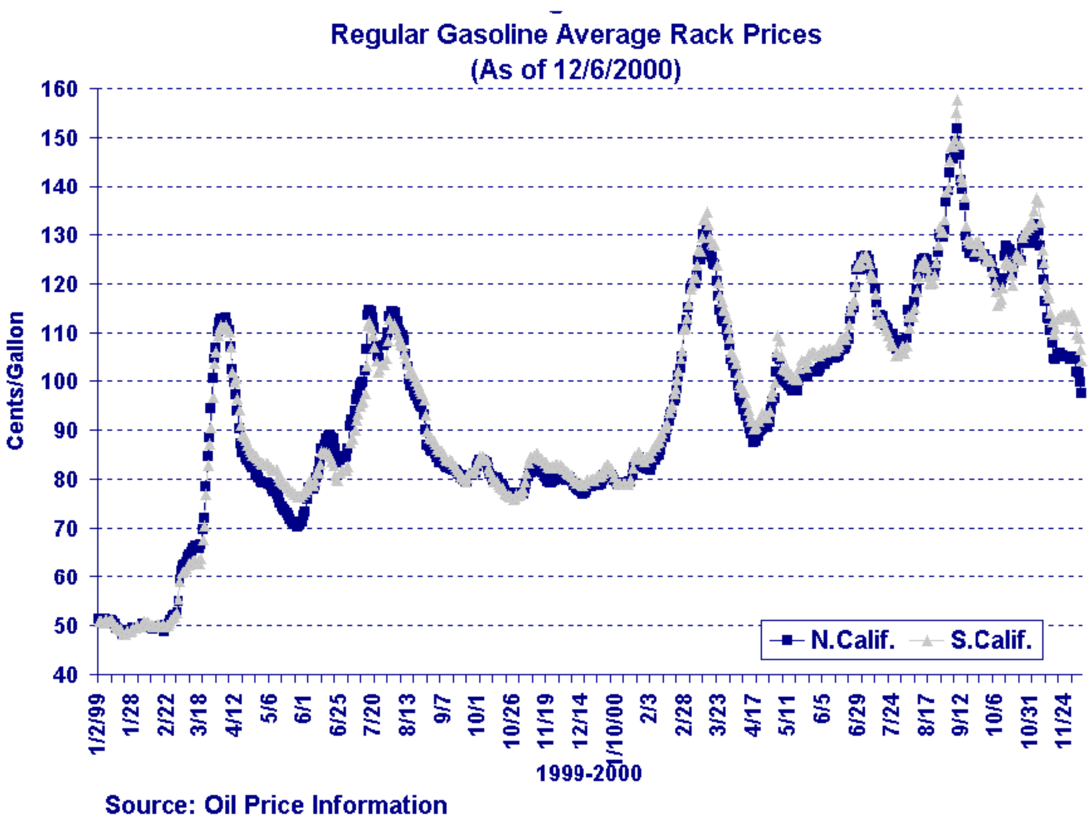


Figure V-6. Wholesale gasoline prices. (Source CEC 1995b)

In conclusion, a California ethanol industry would be more viable if gasoline prices remain high or if the price of ethanol can be assured though contracts with refineries or other mechanisms.

Would Ethanol FFVs Affect the Supply and Price of Ethanol?

A significant number of flexible fueled vehicles (FFVs) that can run on any mixture of ethanol and gasoline operate in California today. At this time, the number is estimated to be about 65,000 and growing to over 100,000 (CECm). Car manufacturers build some vehicles as FFVs to assist in complying with the Corporate Average Fuel Economy requirements for passenger cars and light trucks. The role of FFVs is unclear. However, FFVs should not contribute to an increase in gasoline prices. Ethanol would not be made available as a low cost fuel for FFVs unless there is a surplus of ethanol. The existing fuel tax structure favors blending ethanol in gasoline where it receives a tax exemption valued at \$0.54/gallon. When used as an FFV fuel (with 85 percent ethanol) it receives a tax credit that is worth about \$0.35/gallon to ethanol producers(see Appendix II-A). Sales of ethanol to FFVs could complement seasonal ethanol availability. However, as refinery demand for ethanol increases, gasoline blending would command a higher price than usage as a fuel for FFVs under current tax incentive provisions.

In addition to the effects on energy production and use, ethanol plant operations and transportation would have negative and positive effects on the environment. The following chapter examines the potential impacts of an ethanol production industry on air and water quality and forest health.

CHAPTER VI

EFFECTS OF CALIFORNIA ETHANOL ON THE ENVIRONMENT

VI. Effects of California Ethanol Production on the Environment

A biomass-based ethanol industry in California has both positive and negative effects on the environment. Depending on the economic valuation methods used to monetize (place monetary value on) these effects and the validation of demand for forest treatment, the net economic effects can be calculated as either positive or negative. Many of the effects are related to the removal of biomass from Northern California forests. They vary from reduced forest fire risk due to pre-fire management thinning to possible habitat alteration. Effects may also be felt due to reduced open burning and more landfill diversion. This section discusses these and other effects on air quality, forest health, and water resources.

In the interest of understanding the costs and benefits of environmental effects, it is worth explaining that some effects can be valued according to their “use-value” and others require alternative valuation. For example, one “use-value” of slash removal would be the avoided costs of conducting prescribed burns. Control of invasive plants species or incremental additions of carbon to the forest floor, on the other hand, are “non-use” values that are difficult to monetize. Although methods exist for valuation of these “non-use” services, they require advanced modeling, and they are beyond the scope of this study. Previous cost and benefit analyses of environmental effects have also avoided monetization of “non use” services unless the specific purpose of the study was to do so (Burtraw, 1998). As a result of the limits to this analysis, this section discusses both types of environmental effects. It is important, however, not to arbitrarily add up costs and benefits where they are monetized but ignore them when they have been qualitatively analyzed. As a result, it is not possible add the costs and benefits of environmental impacts to economic costs and benefits in Chapter IV.

VI.1 Emissions Impacts of Ethanol Plant Operation

There will be positive and negative emissions impacts due to ethanol production in California, although the net effect is positive. Forest wildfire, prescribed burning, and open burning of orchard material are all reduced by diversion of biomass to ethanol production. On the other hand, new combustion of by-product lignin, transportation of some feedstocks to plants, and ethanol transportation to terminals add to statewide emissions of nitrogen oxides (NO_x), particulates (PM10, from here referred to as PM), hydrocarbons (HC), carbon monoxide (CO), and carbon dioxide (CO_2). The result is a decrease in emissions for PM, HC, CO, and CO_2. If five biomass power plants are operating prior to ethanol plant collocation, as established in Scenario 1, NO_x emissions are also reduced with a corresponding reduction in electricity production. The extent of the impacts and their costs to California and beyond are discussed below.

Emissions Sources under Zero California Ethanol Production

The case, in which no ethanol is produced in California, includes emissions from several types of sources. It is very important to note that the analysis only covers emissions that would be affected by the establishment of an ethanol production industry. For example, rice straw emissions are not considered since they exist with or without ethanol. Also, biomass power plants that operate under both scenarios are not considered.

Emissions Source	***Explanation***
Biomass Combustion	In Scenario 1, five biomass power plants operating, which would be converted to collocated ethanol plants.
Prescribed Burn	0.01%-0.02% of California forest undergoes prescribed burns in order to improve forest health, reduce the risk of wildfire, and provide firebreaks and fire fighting zones (CDF, 2000).
Wildfire	Approximately 0.5% of California forests burn due to wildfires each year (CDF, 2000). For this study, only areas at risk for wildfire and resulting emissions are areas that would undergo prefire management by reducing fuel loading for ethanol production.
Open Burn	Orchard prunings.
Transportation	Emissions in California due to transport of ethanol from other states by rail and marine vessel; also emissions from feedstock transport for biomass power plants operating.
Total CO_2	Ethanol imported to California from other states causes CO_2 emissions. See Section V.3, Petroleum Use.

California Ethanol Production Emissions Sources

Producing ethanol changes emissions sources relative to the zero ethanol scenario.

Emissions Source	***Explanation***
Biomass by-product combustion	Forest material and agricultural residue (except rice straw) produce lignin, which can be burned in a power plant.
Prescribed Burn	Prefire management by fuel loading removal replaces prescribed burns.
Wildfire	Wildfire emissions reduced significantly: reductions range from 3.5 lbs NO_x/bone dry ton biomass removed to 430 lbs CO/bone dry ton removed (ARB, 2000; see Appendix VI-C).
Open Burn	Agricultural residue diverted from open burning to ethanol feedstock.
Transportation	Feedstock transport by truck; ethanol transported by combination of truck and railroad (see Section III.4 for discussion of railroad infrastructure).
Total CO_2	Ethanol production in California produces CO_2; ethanol produced from corn becomes available for use in other states causing a reduction in gasoline-related fuel production emissions when those other states displace gasoline with ethanol (see Section V.3)

Emissions by Feedstock

The methods to obtain feedstock for ethanol and the various uses for by-products discussed in Section III.5 result in emissions impacts. Since forest material, agricultural residues, and urban waste have different processes causing emissions, they are each discussed below.

Forest Material

Thinning and removing slash from dense forests will reduce prescribed burns and the severity of wildfires, thereby vastly reducing emissions of CO and PM. By thinning small areas or removing slash each year, those areas plus adjacent ones face a reduced risk of wildfire over several years. The time periods range from less than one year to 20 years or more, depending on the vegetation type. Although the emissions do not occur in highly populated areas, their transport does affect the forest ecosystem, nearby communities and large populations further away.

The level of emissions that can be expected from avoidance or less severe wildfires occurring in the areas that are treated are based on the California Air Resources Board (ARB) emission factors. These ARB factors enable analysis of the avoided wildfire emissions per ton of biomass removed. Unfortunately, little is known about the emissions from fires specifically in thinned areas (Forrest). As a result, this study relied on the average values reported by the ARB. As indicated in Figures VI-2 through VI-5, the emissions avoided by removing forest material are shown as emissions incurred in absence of treatment. In other words, the wildfire emissions are not zero in the California ethanol production case, but are shown as avoided emissions in the Zero California ethanol production case.

Despite emissions reductions, there is a shift from one pollutant to another when the biomass is processed for ethanol rather than open burned. For example, reducing PM and HC emissions caused by biomass combustion in wildfires increases NO_x emissions. This is due to by-product lignin combustion in ethanol collocated power plant boilers, which produces more NO_x than a wildfire. See Appendix VI-C for a discussion of forest material emission factors used in this study.

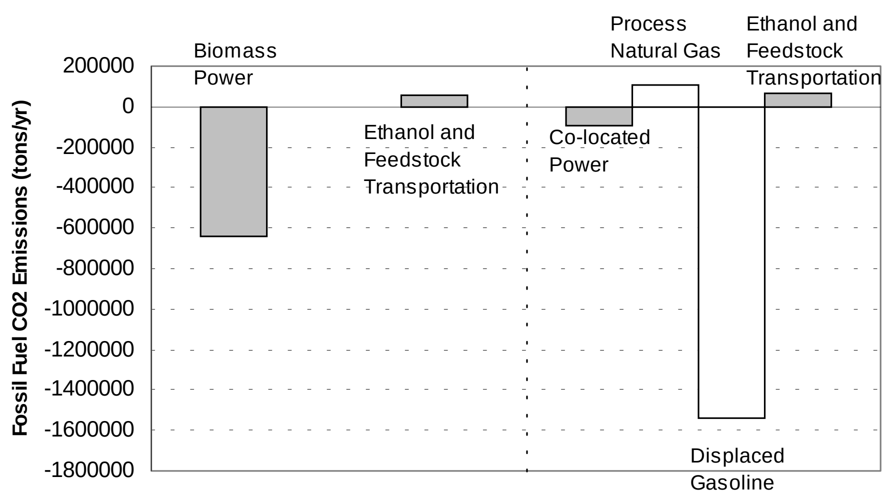
Although NO_x emissions from greater quantities of biomass increase due to the combustion of lignin in a boiler, there are also expected NO_x emissions reductions. These are due to biomass power plant conversion to ethanol production. In the California ethanol production case Scenario 1, five operating biomass power plants will convert to ethanol production. Since the amount of feedstock required from forest materials in the base case is one million BDT/yr, this study assumes that one of the biomass power plants converts to an ethanol plant that uses much greater quantities of forest material than it did previously. Other ethanol plants using forest material are expected to use comparable amounts of biomass.

Because some ethanol production will require new removal and hauling of biomass and all ethanol facilities will require transport of the product, the transportation emissions are greater in the California ethanol production case than in the zero ethanol case, as seen in Figure VI-2 for NO_x. Transportation emissions and emissions factors are discussed in detail later in this section.

Ethanol production from forest material and agricultural residue will increase emissions of fossil fuel CO_2 because diversion of biomass from power production to ethanol will result in increased fossil fuel electricity production elsewhere. The exception is if non-fossil fuels are used for electricity production. In addition, the ethanol production process from urban waste requires natural gas, which produces fossil fuel CO_2 emissions, as seen in Figure VI-1.

If Scenario 2 is considered, in which only one forest material power plant converts to ethanol production, the fossil fuel CO_2 is reduced due to natural gas power being displaced by electricity from lignin combustion. This report, however, has focussed on the likelihood that biomass power plants will be operating prior to ethanol production.

In either scenario, ethanol displaces CO_2 emissions related to gasoline and its fuel production cycle. As discussed in Section V.3, this is due to increased ethanol sales in other states, which displaces gasoline use. These avoided fossil fuel emissions are much greater than the CO_2 related to California ethanol production, as seen in the figure below. The CO_2 released from forest or other biomass combustion or ethanol is not shown because it is a short term storage in the atmosphere and because policy makers are generally more focused on the CO_2 production from fossil fuels.



Note: Positive numbers indicate production of fossil fuel CO_2 while negative numbers indicate fossil fuel CO_2 emissions avoided

Figure VI-1. Fossil Fuel CO_2 Emissions in Zero CA and CA Ethanol Production Cases

Agricultural Residues:

Diverting biomass for ethanol will reduce open burning of orchard prunings. This is important since nearly all orchard prunings are open burned. The use of prunings for ethanol production feedstock will directly reduce this open combustion, which produces high emissions of CO, as seen in Figures VI-2 through VI-5 (see Appendix VI-C for agricultural residue emission factors).

Although rice straw will be used as ethanol feedstock, it is unlikely that rice straw burning will be reduced under a California ethanol production scenario. As pointed out in Section III, only a limited amount of rice straw burning will be permitted by air quality regulators. Since this form of disposal is the least expensive option, it will be pursued to its limits. Therefore, unless the price of ethanol is high enough to offset the cost to bale and transport rice straw, such that it is less than the cost to burn, combustion emissions will not be displaced by ethanol demand.

In this analysis, agricultural residues are used in conjunction with seasonal rice straw in ethanol plants. Only these types of ethanol plants are employed in the California ethanol production scenario. As is much the case with forest materials, the burning of agricultural residue lignin shifts emissions from PM, CO, and HC to NO_x. Figures VI-2 through VI-5 illustrate this effect.

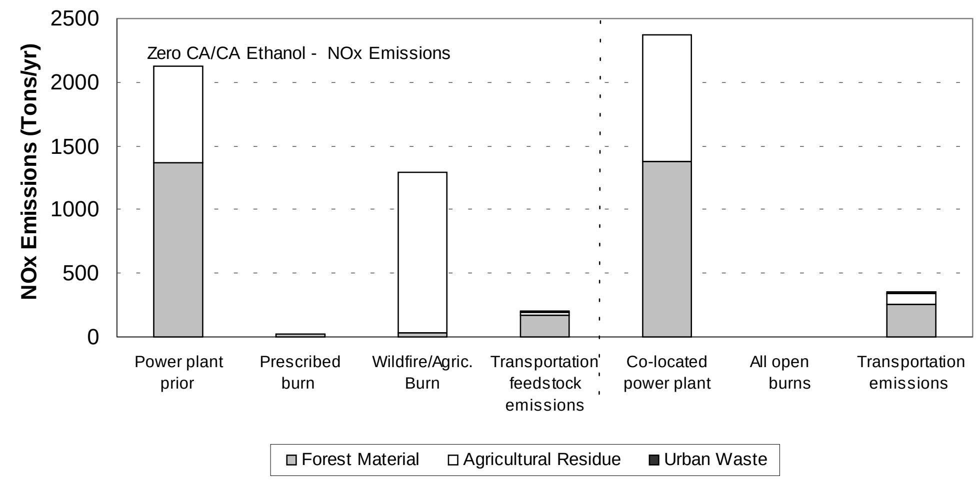


Figure VI-2. NO_x Emissions in Zero CA and CA Ethanol Production Cases

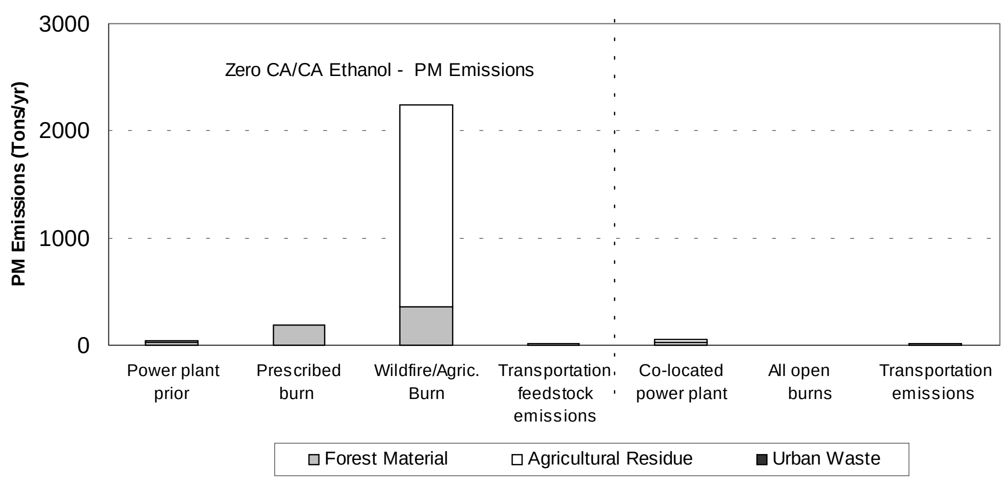


Figure VI-3. PM Emissions in Zero CA and CA Ethanol Production Cases

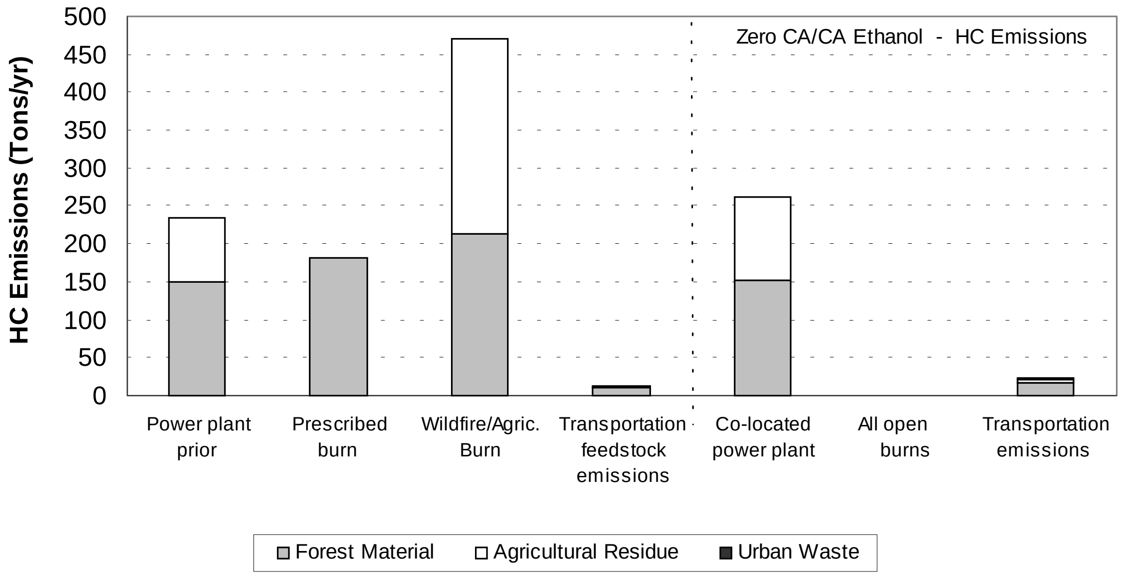


Figure VI-4. HC Emissions in Zero CA and CA Ethanol Production Cases

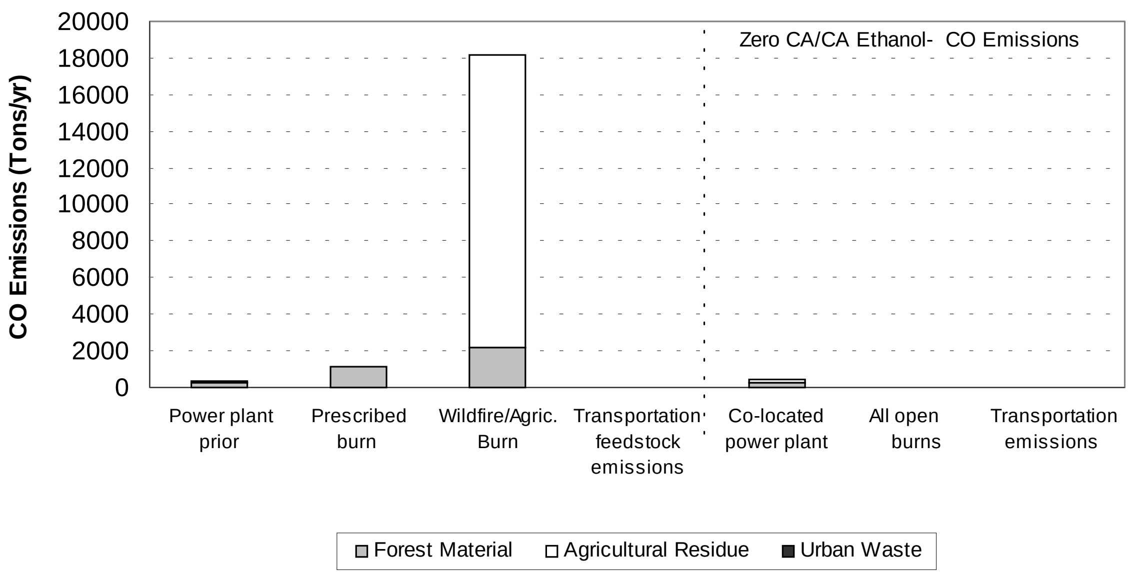


Figure VI-5. CO Emissions in Zero CA and CA Ethanol Production Cases

Urban Waste

Urban waste disposal is likely to produce comparable emissions whether or not the material is used as feedstock for ethanol production. This is due to the fact that the transportation emissions under the California ethanol production case are comparable to conventional waste treatment since transport from the waste sources to a MRF is needed in both cases. It is assumed that the ethanol facilities are collocated with MRFs. Finally, the increased NOx experienced with other feedstocks due to by-product electricity production is not applicable for urban waste. No by-product combustion is allowed in an urban waste-to-ethanol facility due to air pollution concerns and difficulty in siting a new combustion source.

The inability to combust by-products for steam and electricity creates a need for imported electricity and other process fuels, which leads to an increase in fossil fuel CO_2. The increases in other pollutants are not significant, as seen in Figures VI-2 through VI-5. As a result, increased fossil fuel CO_2 is the greatest emissions impact of ethanol from urban waste.

Transportation Emissions

Ethanol feedstock and fuel transportation emissions are much less than the emissions from co-product combustion or open burning. Nevertheless, the truck, rail, and marine transport do contribute to pollution levels and have therefore been quantified in this study. Table VI-1 shows the estimated emissions of CO_2, NO_x, PM, HC, and CO under the California ethanol production scenario.

Transportation emissions result from a combination of trucks, rail, and marine vessels, as discussed in Section III.4. In the zero California ethanol production scenario, rail and marine vessels transport ethanol from out-of-state, as shown in Figure VI-6. The emissions are counted once the rail cars or marine vessels are within the state boundaries, except for CO_2, which has global accounting due to its global effects.

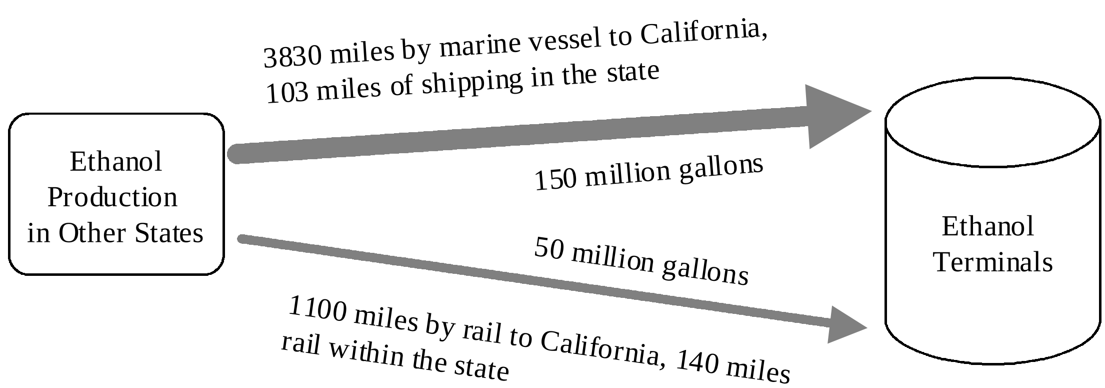


Figure VI-6. Transportation scheme if California produces no ethanol

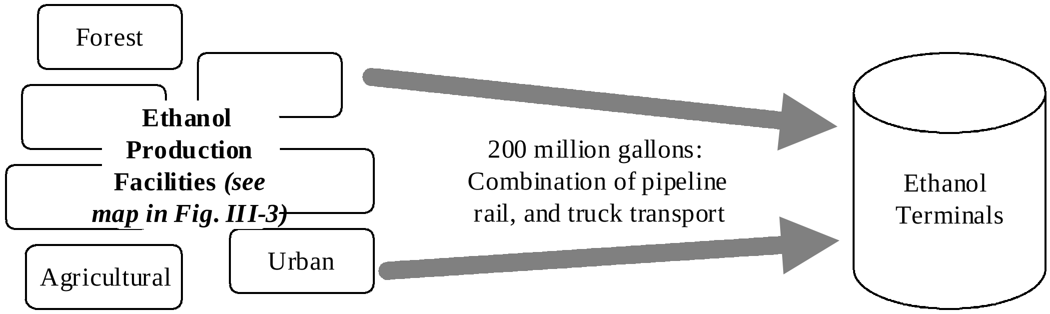


Figure VI-7. Transportation scheme if California produces 200 million gallons of ethanol

If California produces 200 million gallons of ethanol from a resource mix of forest material, agricultural residue, and urban waste, the transportation requirements are different from the imported ethanol case. The emissions, in this case, are due to trucks bringing feedstock to ethanol plants, and trucks and locomotives transporting ethanol to distribution terminals. The transportation of the ethanol is shown in Figure VI-7. The emissions factors used for this analysis are based on EMFAC 2000 and are shown in Appendix VI-C.

Table VI-1. Transportation emissions for 200 million gallons of ethanol transported to terminals and feedstock movement activities (tons/yr)

Production Case	NO_x	HC	PM	CO	CO_2
California Ethanol Production	**353**	**23**	**13**	**35**	**66,400**
Forest Material	256	17	10	27	45,000
Agricultural Residue	81	5	3	7	17,000
Urban Waste	16	1	.4	1	4,000
Zero California Ethanol Production	**99**	**9**	**4**	**11**	**65,000**
Feedstock Transport	72	5	3	7	39,000
Ethanol Transport	28	4	1	3	26,000

The greatest transportation requirements are in the forest biomass sector since nearly half of the ethanol will be from forest biomass plants that are fairly remote. Table VI-1 above shows that this leads to the highest emissions from transport of forest materials and their ethanol product. Although a portion of the total transportation emissions occurs in urban areas, the configuration of a greater number of smaller ethanol plants prevents longer truck travel in these regions. As a result, the transportation emissions related to urban waste-based ethanol are small, not to mention that the urban waste ethanol emissions are not noticeably greater than urban waste disposal emissions in a zero California ethanol case.

The comparison of CO_2 emissions from ethanol transportion from the Midwest and within the State revealed that emissions are slightly greater when California imports ethanol. This difference is not significant, however, especially because transport within the corn states was not considered.

Although the transportation emissions for other pollutants in a California ethanol production case are greater than in the zero ethanol production case, the previous section discussing ethanol plant emissions and Figures VI-2 through VI-5 demonstrated that the alternative feedstock burning produces emissions several magnitudes higher. As a result, the transportation emissions do not play a major role in determining the benefit of supporting an ethanol industry.

VI.2 Impacts of Biomass Harvest on Forest Health and Water Resources

This section summarizes the key assumptions, results and conclusions of a qualitative evaluation of the potential impacts and risks to forest health and water resources that may result from the removal of biomass from managed forests for use in ethanol production. A more detailed discussion of these impacts and risks, and their potential mitigation, appears with full literature citations in Appendix VI-A.

Assumptions and Biomass Harvest Scenarios

The nature of potential adverse and beneficial ecological impacts to forests and associated water resources will vary from site to site. This is due to the diversity of forest and other plant communities that may be targeted for biomass removal to support ethanol production. We assume that ecological impacts can be minimized if removal of slash from logged areas can be targeted at the most accessible, economic, and least ecologically sensitive forest units. Slash removal for ethanol production would be integrated with slash removal for the purposes of fire prevention and forest sanitation, as in disease and insect control.

California's Forest Practice Rules regulate current logging, thinning, and slash treatment practices. The principles stated in these rules are designed to avoid or minimize adverse impacts on soils, forest productivity, biological diversity, wildlife and endangered species, flooding, water quality, and fisheries. For this report, it is assumed that biomass removal for ethanol would coincide with logging and slashing treatments that conform to California's Forest Practice Rules. It is also assumed that these rules will be used to focus selective removal of slash on the least vulnerable sites and forests.

The following assessment considers impacts to forest health that might be expected, when and if adverse impacts are mitigated to the maximum extent practicable, by conforming to the silvicultural methods prescribed in the Forest Practice Rules for different types and site-specific sensitivities of forests. A detailed assessment, with full citations for relevant forest ecological literature, is presented in Appendix VI-A.

Potential Adverse Impacts and Mitigation

Soil Damage and Depletion of Soil Nutrients

The U.S. Forest Service and many forest ecologists agree that soil compaction and erosion is an inevitable consequence of silviculture and timber harvesting. Heavy machinery used in forest operations and the construction and presence of roads, landings, and skidder trails compact, disturb, and scarify soils (e.g., Beschta et al., 1995; Frost, 1995; Rhodes and Purser, 1998). Examples of clearcut timber harvesting, which can have adverse impacts on soil retention and nutrients, are illustrated in Figure VI-8. Although soil erosion can be exacerbated by slush removal when such clearcuts occur on slopes and erodible soils, forest thinning has much less impact on soil.

Figure VI-8. Impact of Logging Operations

Depending on site conditions and the scale of harvesting and thinning operations, these activities can damage forests and water resources to varying degrees by decreasing soil permeability, tree root growth, and water storage capacity while increasing surface runoff, soil erosion and sedimentation of streams. Studies of forest nutrient cycles in relation to timber harvest and silviculture show that biomass removal from forests, as pre-commercial thinnings, whole trees, logs, and slash, can deplete soil organic matter/carbon and other nutrients essential for plant growth and floristic diversity (Jug et al., 1999; Olsson, 1999; Vesterdal et al., 1995; Jacobson et al., 2000; Yanai, 1998).

Hydrology and Flooding

Soil compaction from harvesting and thinning machinery decreases rain and snowmelt infiltration (Rhodes and Purser, 1998). Logging road cuts intercept shallow subsurface ground water flows, thus acting as tributaries that increase the diversion to streams of overland, sheet-flow runoff that otherwise would infiltrate forest soils. This leads to increasing peak surface water runoff and downstream flooding, while reducing soil water storage, ground water recharge, and the gradual release of base flows of ground water to streams and wetlands throughout the growing season. The large increases in peak surface runoff associated with clearcuts and other harvesting methods cause scouring and erosion of stream banks and channels, leading to sediment buildup, water quality degradation, and reduced flood retention capacity in reservoirs. However, such impacts are much less significant for thinning operations, especially when no new road construction is required.

Food Chain, Fish, and Wildlife Impacts

Biomass removal of organic matter reduces the leaflitter, twigs, and other nutrients on the forest floor available to decomposers such as invertebrates, beneficial insects, and fungi. These form the foundation of forest nutrient cycles and food chains that support local wildlife. Logs, snags, and living trees targeted for biomass removals can harbor disease and increase fire risk but also provide habitat for wildlife and their prey (see Figure VI-9).

Figure VI-9. Examples of Biomass/Fuel Accumulation in Hardwood (right) and Unthinned Spruce (left) Forests

Silvicultural operations and timber harvest and thinning lead to unavoidable increases in erosion and stream sedimentation. This results in some degree of water quality degradation and adverse effects on sensitive fish populations and their habitats, especially salmonids such as salmon and trout. Figure VI-10 illustrates a typical area where riparian forest has been well managed as a buffer zone to prevent erosion and thus water quality in preserving native California Salmon stream habitats.

Figure VI-10. Eel River Riparian Zone Redwood Forest – Potential Salmon Habitat

Impacts on undocumented habitats of protected fish and wildlife species are the most significant risks posed by removals, and related silvicultural operations may not conform to the Endangered Species provisions of the Forest Practice Rules. As with impacts to all ecological receptors, however, normal forestry operations often put wildlife and endangered species at risk whether or not any biomass removal is conducted. (See Appendix VI-A.)

Mitigation of Adverse Forest Impacts

Because potentially adverse impacts of silvicultural and timber harvest operations are unavoidable, they will occur whether or not biomass is removed from the forests for purposes of fire prevention, forest sanitation, and/or ethanol production. While removal of diseased trees, and diseased or healthy slash and thinnings from the forest poses a small incremental ecological impact, this will be offset by reduced fire/disease risks to forest health. Although the significance of this increment would be greatest at nutrient limited stands and other sites that are most sensitive to biomass removal, such forests can be selectively avoided because the biomass demand for ethanol is less than 15% of the slash and thinnings available (CEC, 1999). If adequately designed and sensitively implemented, post-thinning mitigation of impacts from logging roads, soil scarification, biomass removal, and other habitat alterations will offset potential adverse impacts of biomass removals.

Potential Beneficial Forest Impacts

Reduced Damage from Fires and Fire Fighting

Wildfire damages to forest health and associated aquatic ecosystems include direct damage to flora and fauna and indirect fire impacts that are mediated by reduced soil quality, death of soil organisms and seeds, floristic changes, habitat loss, and impaired nutrient and water cycles (e.g., Chabot and Mooney, 1985; CBEA, 1997; Morris, 1998; Neary et al., 1999). Fire fighting activities (e.g., road cuts, fire breaks, stream water removals) and post-burn timber salvage operations exacerbate these direct impacts with further disturbance of the fire-damaged soils, forest hydrology and habitat/water quality of associated aquatic habitats (e.g., Beschta et al., 1995; Frost, 1995; Rhodes and Purser, 1998). Silvicultural methods such as slash removal can reduce fire intensity without significantly disrupting nutrient cycles at all but the most nutrient-limited sites (e.g., Stephens, 1998; Monleon and Cromack, 1996). As a result, the prevention of intense fires by removals of slash, thinnings and diseased trees/snags/logs from fire-prone areas will have the benefit of reducing direct and indirect damages to forested watersheds.

Optimized Carbon Assimilation and Growth

Photosynthesis, carbon assimilation, and growth of the desired/retained trees result from their sudden release from competition for sun, water, and soil nutrients with vegetation being removed. Competition for soil nutrients is reduced significantly by pre-commercial and commercial thinning. So the slight incremental increase in nutrient losses from the forest caused by removal of slash or thinned tree trunks is negligible. In most situations, thinning will enhance carbon gain, growth, and wood formation by the retained trees, despite the removal of additional nutrients as biomass used for ethanol purposes.

Improved Timber Yield and Quality

Thinning provides greater light availability and increased spacing that allow trees to attain their full genetic potential for optimal wood production and quality. Figure VI-11 illustrates a managed pine forest that has been thinned to enhance timber quality and yield per tree**.** Biomass removal should be targeted at forest stands that would not suffer a decline in wood production due to even very small removals of nutrients, or other adverse effects of mechanized thinning such as soil compaction and scarification.

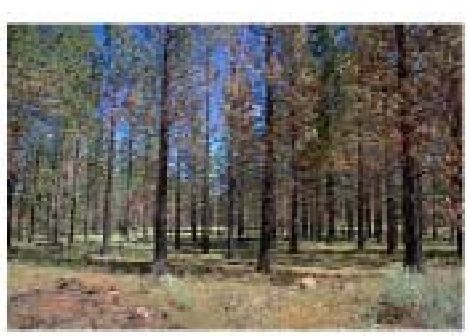


Figure VI-11. Example of a Managed Forest

Better Forest Sanitation and Insect and Disease Control

Pine and spruce bark beetles and other insects damage trees directly and may transmit tree diseases, such as pitch canker disease in pines, leading to tree death and the resultant buildup of fuel as standing dead wood. Since the only known control for this fungal disease is forest sanitation, removals of infested trees, slash and other biomass for use in ethanol production can help reduce disease outbreaks. Insect and other disease infestations and epidemics are exacerbated by drought, which can render even healthy trees susceptible to infection. Sudden Oak Death, caused by a combination of beetles and the fungus *Hypoxylon*, poses a threat to California's limited oak forests while also increasing the risk of fire from increased amounts of fuel contributed by the dead trees (Figure VI-12). Slash and other forest biomass removal needed for the combined purposes of disease control, fire prevention, and ethanol production should be timed to precede drought conditions, to optimize this preventative measure. Removal of diseased trees/biomass also can reduce the risk of fire-mediated disease transmission to healthy forests because spores of pathogenic fungi also can be entrained in smoke and carried considerable distances without losing their viability.

Figure VI-12. Fruiting Bodies of Hypoxylon Fungus (left) and Oak Ambrosia Beetle (right).

Control of Invasive Plant Species

Thinning of forests can remove undesirable species of trees, shrubs, and herbs, including introduced species of noxious, invasive weeds. At the same time, it can enhance the growth of native species of shrubs and herbs that promote biodiversity but do not significantly compete with the timber trees for root space, water, light, or nutrients. Since undesirable weeds more easily invade a forest after high intensity fires, slash removals for use as biomass can reduce the risk of fire-potentiated invasions of forests by non-native plants.

Hydrology, Flooding, and Water Quality

By reducing the severity of forest damages from fires, insects, and disease, periodic removals of infected and combustible biomass will indirectly reduce erosional and combustion losses of soil organic matter and nutrients. These losses collectively reduce the water holding capacity of soil and undermine soil stability, thus increasing peak surface runoff rates and exacerbating downstream flooding. Therefore, efforts to reduce the frequency and intensity of forest fires, such as biomass removal, can benefit forest hydrology, flood control, water quality, and the health of aquatic ecosystems and their resident fish communities. Well-managed forests of riparian zones, for example, offer critical spawning and rearing habitat for protected, economically important fish such as salmon.

Summary of Forest Impacts

When compared to the ecological impacts of normal forest management and harvesting activities, the incremental of impact from biomass removals of slash and thinnings are small for all but the most sensitive, nutrient-limited forests. Moreover, the extent of the damage to forests caused by intense fires and disease epidemics often justifies removals of biomass for the dual purposes of fire prevention and pest control. Assuming that biomass removals will be carefully targeted and conducted in conformance with the California Forest Practice Rules, while employing ecological impact mitigation measures designed for site-specific conditions, these will be a beneficial impact on the health of forests.

VI.3 Landfill Diversion: The Value of Preserving Intangible Resources

Some research has been done in the academic field to determine whether people may place some monetary value on intangible environmental benefits. Such intangible benefits include the value that people may place on the knowledge that pristine undeveloped areas are preserved in their natural state, or that an outdoor area is not converted into landfill. See Appendix VI-B for discussion of valuation. It is possible to report these values and attempt to incorporate them into more conventional accounting methods. Unfortunately, none are known to specifically address the value of leaving the option for later use of land now being converted to landfill. Nevertheless, some people do place monetary value on these types of intangible environmental benefits, even though they may not receive any direct or tangible benefit.

As some people currently pay a premium for the provision of “green power” to their homes, so they may pay a premium on their garbage collection bill to support landfill diversion efforts. Some members of the public might be willing to subsidize the production of ethanol from MSW or other feedstocks in this manner. Therefore, an environmental economic study could be conducted to monetize the consumer value of landfill diversion. One method of valuation is a survey that could be employed to quantify the dollar amount of the subsidy that residents would support, as well as the percentage of residents that would be willing to participate. While choosing a method and carrying out a study to value this service is beyond the scope of this report, a further study could determine the degree to which the public supports landfill diversion with ethanol production.

Another possible indication of the monetary value that California places on such environmental benefits is the amount of money appropriated by the legislature in recent years to subsidize activities and business that contribute to "green" power generation and landfill longevity. In 1999, in AB1890, the California Legislature appropriated a total of $540 million to subsidize the production of electricity by renewable means. Of that total, $135 million was used to specifically support the biomass and solar thermal industries. Since one of the rationales for providing this support to the biomass industry was to help divert solid waste from the State's landfills, this bill may give some indication of the monetary value that the public sector places on the environmental benefit of solid waste diversion.

VI.4 Costs and Benefits of Environmental Impacts

As discussed earlier, it not possible in this study to place monetary value on all environmental impacts. This study monetized the emissions impacts associated with an ethanol industry based on several types of feedstocks. Other studies have attempted to evaluate the economics associated with emissions reductions, changes to water resources, and fire risk reduction due to removal of biomass from forests and agricultural residues. These studies focussed on these feedstocks because they were conducted primarily for evaluation of biomass based power industries.

The range of benefits for wildfire risk reductions reported by previous studies is rather large due to the varying valuation and monetization methods. Some studies include avoided fire protection costs and asset losses while others include only avoided fire protection costs in the value of reduced wildfire risk. The ranges of values for impacts are shown below in Table VI-2.

Table VI-2 Economic Values for Various Environmental Impacts

Impact	Range of Values ($/BDT removed)	Sources
Open Burn Emissions Reduction	2-50	CBEA/Cal EPA 1997; NRSS/CEC 1997
Wildfire Emissions Reduction	0.27-50	CBEA/Cal EPA 1997; NRSS/CEC 1997
Greenhouse Gas Reductions	33	CBEA/Cal EPA 1997
Wildfire Risk Reduction	3-36	CBEA/Cal EPA 1997; NRSS/CEC 1997; FRA/NREL 1997
Forest Health Improvement	0.07	NRSS/CEC 1997
Increased Water Assets	unclear - 3	CBEA/Cal EPA 1997; FRA/NREL 1997

Note that the report by Natural Resources Strategic Services, which describes the benefits of biomass power in California (1997) found forest health improvement to be less than one dollar. Other studies did not attempt to determine this value. Further studies are necessary to evaluate the costs and benefits to the forest due to biomass removal.

The range of values for emissions benefits in Table VI-2 are close to those calculated independently for this study. This study chose to place a monetary value on emissions reductions based on the history of society's willingness to pay for better air quality (see Appendix VI-B for more discussion). In particular, the study chose an avoided cost method, one of several types of valuation, to monetize the emission levels from ethanol production discussed in Section VI.1 and summarized in Table VI-3. Since the State and many air districts are making an effort to reduce air pollution through control measures, it is appropriate to value the emissions impacts according to avoided control costs for particular pollutants and sources. This type of valuation employs average rates for emissions trading credits or reduction effectiveness factors and is commonly used to determine the value of pollution reductions in the State. They take into account the marginal costs for incremental environmental improvements, such as road dust reduction for PM, gasoline car emissions reductions for HC, fuel economy improvements for CO_2, and power plant emission reductions for NO_x.

Although other costing methods are sometimes used to evaluate the economics of pollution impacts, it is most appropriate to use the avoided cost of emissions offsets since the market trades the same pollutants as those impacted by ethanol production.

California average trading factors for NO_x, PM, CO, and HC in 1999 are listed in Table VI-4. These factors are the average of actual prices paid throughout California in 1999 for permits to pollute (California Air Resources Board, 2000). In addition, CO_2 is worth approximately $25 per ton. Although CO_2 is not a traded pollutant, its value is associated with the cost to reduce CO_2 emitted from power plants.

Table VI-3. Values of Emission Benefits of Ethanol Production

	NO_x	PM	HC	CO	CO_2
Cost for Offset ($/ton)	$13,884	$10,400	$6,579	$3,033	$25
Tons of Reductions per year	-2000	7000	2000	52,000	870,000
Estimated Value of Ethanol Production over Zero CA Ethanol per year	-$23 M	$70 M	$10 M	$158M	$22 M
Estimated Value of Ethanol Production over Zero CA Ethanol per BDT of feedstock	9	26	4	59	8

Total Estimated Value per year	$280 M

Using these factors and the emissions differences between the zero California ethanol case and the California ethanol case, the economic benefits can be calculated, as seen in Table VI-3. The total value for emissions changes from wildfires, open burns, power plants, and transportation add up to approximately $100/BDT. This is within the ranges found in other studies shown in Table VI-2.

The emissions reported above and those shown in Figures VI-2 through VI-5 rely on emission factors for wildfires, prescribed burns, and biomass power plants. This study made an effort to choose the most appropriate emissions factors. Appendix VI-C shows the variety of emissions factors available particular values chosen for this analysis.

Several assumptions about forest wildfire and control activities shown in Table VI-4, below, have an effect on the values above. A sensitivity analysis is ideally required to determine the possible range of estimated emissions. For example, the study required values for the amount of biomass removed per acre during prescribed burns and forest management thinning. Since a previous study by the Quincy Library Group found the average thinning in similar forests to be an average of 12.5 tons per acre, this value was applied to the analysis (1997). This value was also in the range of 7-15 tons per acre used for ongoing studies (Forrest). Unfortunately, no data was available for average density of biomass removed by prescribed burns, especially since vegetation and site-specific characteristics vary widely. Therefore, this study chose a conservative estimate based on the assumption that more material is left in the forest after a prescribed burn than a forest thinning treatment.

If the assumption for prescribed burn removal is too low and more material is removed, the emissions from the prescribed burn combustion will be greater, driving the zero California ethanol scenario emissions higher. As a result, the reduction in PM, HC, and CO emissions from the zero ethanol case to the California ethanol case will be more profound. In the same situation, the negative NO_x impact caused by burning biomass in a boiler rather than in an open burn will be less significant because the zero ethanol scenario emissions will be higher.

In order to verify the forest management estimates in Table VI-4, the study's assumptions need to be re-addressed as more information is known about the density and vegetation characteristics of the forest locations being considered for ethanol feedstock. For example, the affected areas either need to be visited for this purpose by forestry experts or detailed Forest Service and CDF geographic information system maps must be consulted to determine the assumptions appropriate for each particular region.

The effects of other assumptions used in this study on the overall impacts of a California ethanol industry are outlined in the "Sensitivity Analysis", in the following chapter.

Table VI-4. Major Assumptions that Affect Environmental Impacts of Ethanol Production.

Attribute	Value Used in This Study	Source
Tons of biomass burned per acre in a prescribed burn	4 tons/acre	—
Tons of biomass burned per acre in a forest fire	15 tons/acre	California Department of Forestry, ARB
Tons of biomass removed per acre in thinning operations	12.5 tons/acre	Quincy Library Group
Number of years of forest fire protection afforded by thinning and slash removal operation	10 years	—

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CHAPTER VII

SENSITIVITY ANALYSIS

VII Sensitivity Analysis

The costs and benefits of a California ethanol industry depend upon several key parameters. The relationship between assumptions and the outcome of the study are shown in Table VII-1.

Table VII-1. Effect of Assumptions

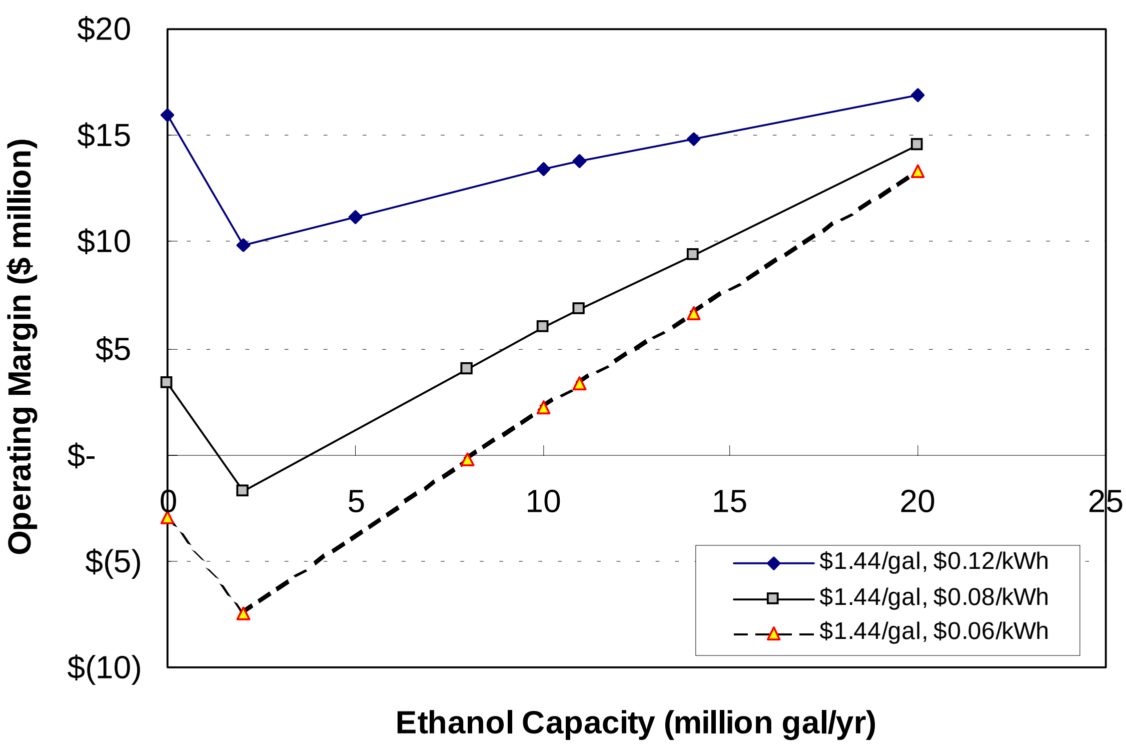
Assumption	Affect to Costs and Benefits
Viability of biomass power (economic impacts)	A long-term viable biomass power industry diminishes the economic benefits (or adds opportunity cost) to a California ethanol industry, Scenario 1 in Chapter V (see Figure V-1a). In Scenario 2 (see Figure V-1a), the power produced by the ethanol industry will increase the total electricity and offset a faltering biomass power industry.
Viability of biomass power (environmental, resource impacts)	A long-term viable biomass power industry would result in similar forest fire reduction, forest health, and air pollution reduction benefits. Ethanol plant operation would result in lower NOx emissions as some of the feedstock would be converted to ethanol rather than burned.
Ethanol price	Lower ethanol prices reduce income to a California ethanol industry and potentially reduce ethanol production. Higher ethanol prices increase benefit to California assuming fixed ethanol demand.
Electricity price	For power prices above $0.10/kWh biomass power appears economically viable. Ethanol investment could be utilized less.
Feedstock price	High feedstock prices reduce the amount of biomass power and ethanol that would be produced. At constant levels of ethanol production, high feedstock prices result in expenditures in California.
Support for ethanol industry	Depending upon ethanol prices, State outlays may be necessary.
Federal ethanol subsidy	Impact depends upon oxygenate mandate. Without an oxygenate mandate, reduction in the ethanol subsidy would result in lower wholesale ethanol prices.

The effect of these parameters on the economic costs and benefits to the state requires the examination of additional scenarios that take into consideration the possible energy prices in California as well the potential fate of the biomass power industry. The economics of ethanol production as well as the potential costs and benefits depend on the operating margin for ethanol and biomass power plants.

Figure VII-1 illustrates the effect of ethanol plant operating capacity on the operating margin for a collocated biomass ethanol plant. The operating margin takes into account the small producer credit which provides and additional $0.1/gallon for the first 10 million gallons of production capacity. This analysis also includes a hypothetical $0.36/gal subsidy as a basis for examining costs to the State. The results of the analysis indicate that even ethanol production appears more attractive than power production (assuming a $0.36/gallon subsidy) when power prices are below $0.1/kWh. Therefore, in a situation with very high power prices capital investments from the State may not be fully utilized. Operating support such as producer price payments would not result in a cost to the State if no ethanol were produced.

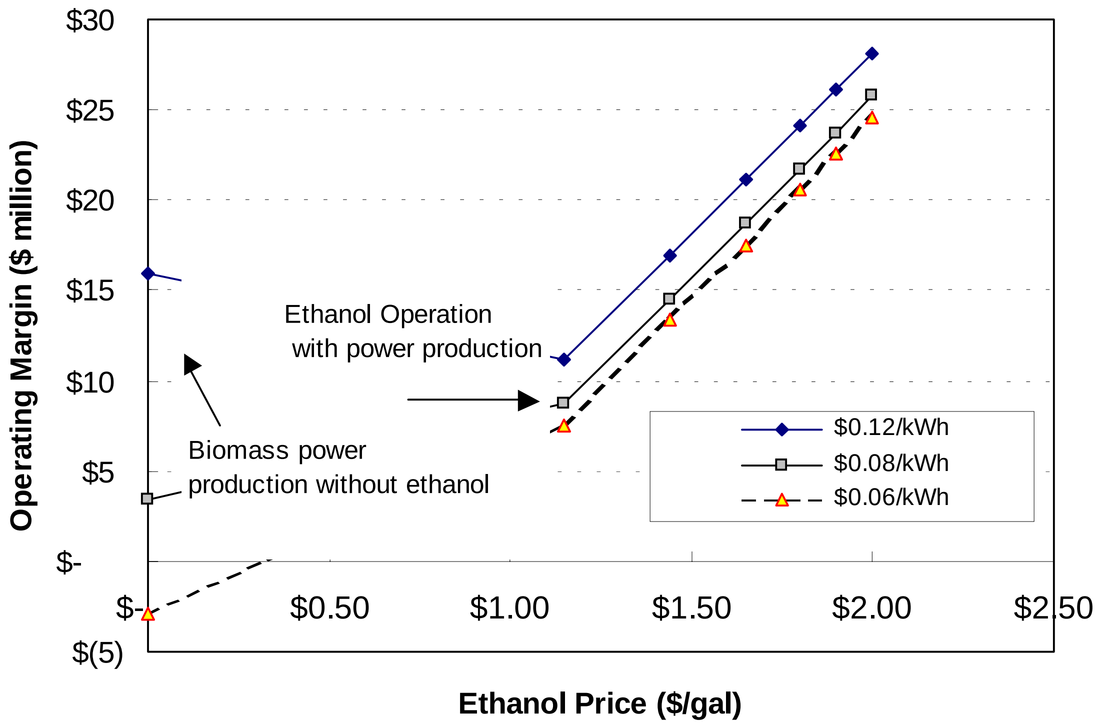
Similarly, Figure VII-2 illustrates the effect of ethanol prices on the operating margin for a biomass power/ethanol plant. A sales price of $1.44/gallon is necessary to recover investment in the facility for the facility considered in this analysis. However, the facility may still produce fuel at lower prices. The alternative margin that would be achieved by burning the feedstock to produce biomass power is shown for comparison.

Given the range of potential ethanol and power prices, the potential economic costs and benefits need to be examined for a range of possibilities that could apply to biomass facilities.



( ) Indicates negative values

Figure VII-1. Effect of ethanol production capacity on collocated ethanol plant operating margin.



( ) Indicates negative values

Figure VII-2. Effect of ethanol sales price on collocated plant operating margin

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

VIII. Conclusions and Recommendations

Conclusions

See Executive Summary

Recommendations

Recommendations will be developed following the public hearing in February.